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# BIOSTRATIGRAPHY AND PALEONTOLOGY OF LATE CAMBRIAN TO LATE MIDDLE ORDOVICIAN CONODONTS FROM SOUTHWESTERN DISTRICT OF MACKENZIE, NORTHWEST TERRITORIES

BY

© RAVINDRA S. TIPNIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled "Biostratigraphy and Paleontology of Late Cambrian to Late Middle Ordovician Conodonts from South Western District of Mackenzie, Northwest Territories" submitted by Ravindra S. Tipnis in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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C R Barnes
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External Examiner

Date ..7/May/78..................

This thesis is dedicated to my parents

*Ma* and *Bhai*

to whom I owe more

than I can ever hope to repay.

# ABSTRACT

Ordovician strata of the South Nahanni River area occur both as a fine clastic facies in the Selwyn Basin (Rabbitkettle and Road River formations) and as carbonate facies with shelly faunas in the Root Basin (Broken Skull, Sunblood, Esbataottine, and Whittaker formations). The lithofacies are controlled by major tectonic features, namely the Redstone Arch, the Selwyn Basin and the Root Basin. Conodonts are present in rocks of both facies and are represented by distinctly different faunas.

The carbonate facies of the Root Basin and the region immediately south of the Redstone Arch contains a complete record of shelly faunas of Canadian to at least Kirkfieldian age, and yields conodonts of predominantly Midcontinent type. A large component of the Canadian fauna consists of North Atlantic elements. Recognized here are the late Canadian Faunas D and E of Ethington and Clark (1971) and Middle Ordovician Faunas 1-9, 10? of Sweet _et al_. (1971). The Broken Skull Formation generally consists of sequences of carbonates that are variably sandy and contains, in its highest parts, the late Canadian Faunas D and E and earliest Whiterockian Faunas 1 and ?2. The Sunblood Formation consists of generally resistant, red-orange-buff weathering limestones and minor dolostones and contains conodonts diagnostic of Whiterockian Faunas (?2-4) and Chazyan Faunas 5 and 6. The Esbataottine Formation proposed by Ludvigsen (1975) comprises moderately recessive, grey-buff weathering limestone and contains upper Fauna 6, Fauna 7, and lower Fauna 8. The lower Whittaker Formation consists of limestones, dolostones and shales, and contains conodonts belonging to Faunas 8, 9

and ?10 (Rocklandian to ? early Shermanian).

Conodonts from the clastic facies of the Selwyn Basin are present in the Rabbitkettle and Road River formations. The thin-bedded argillaceous limestones of the Rabbitkettle Formation yield sparse but distinctive Late Cambrian (*Proconodontus* Zone of Miller, 1975 to earliest Ordovician (Faunas A, ?B) conodonts. Their biogeographic affinities are unclear. The argillaceous limestones of the Road River Formation contain a diverse and fairly rich North Atlantic type conodont fauna, including *Oepikodus evae* (Lindström), *Eoplacognathus planus* (Sergeeva), *Pygodus serrus* (Hadding) and *Amorphognathus superbus* (Rhodes).

The restriction of the Midcontinent faunas to the carbonate deposits of the southern Mackenzie platform and that of the North Atlantic fauna to the deepwater clastic facies of the Selwyn Basin, clearly emphasizes the dependency of these two biogeographic faunas on ecological factors present. Based on the study of conodonts from both the Root and Selwyn basins, the following distributional pattern emerges for the Middle Ordovician conodonts, arranged in approximate order from biofacies close to paleoshore to those farther away, on the continental slope: 'Biofacies' I, near shore dominated by 'Fibrous' conodonts; 'Biofacies' II, shallow shelf, dominated by *Plectodina*; 'Biofacies' III, deep shelf, dominated by *Phragmodus*; and 'Biofacies' IV, slope/basinal, dominated by *Periodon*/*Amorphognathus*.

The total conodont fauna studied can be assigned to 41 multielemental genera, 18 form genera; 98 multielemental species , 70 form species and one subspecies. Of these 4 multielement genera, 14 multielemental species, 3 form genera, 5 form species and one subspecies are new.

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# CHAPTER I

# INTRODUCTION

## A. Objectives of the Study

Ludvigsen (1975) demonstrated that the Ordovician strata of the South Nahanni River area consist almost entirely of fossiliferous carbonates of platform/slope facies and contain diversified and useful macrofossils (trilobites and brachiopods) which provide important biostratigraphic, biogeographic, paleoecologic and paleontologic data. Ludvigsen (op. cit.) also established a zonation scheme for the Middle Ordovician rocks of the region, which was based mainly on the distribution of trilobites from the platform facies, and reviewed the general stratigraphy of the area. Many of Ludvigsen's collections were also studied for ostracodes (Copeland, 1974) and conodonts (Tipnis *et al.*, 1975; in press), while Chatterton and Ludvigsen (1976), in another study, described an excellently silicified trilobite fauna from the Esbataottine Formation, and considered its paleoecology. These studies have clearly demonstrated the uniqueness of this region, and significance of the fauna in terms of Ordovician stratigraphy and paleontology.

The present study is a further documentation of the faunas of this region. The emphasis here is primarily on the paleontology and biostratigraphy of the conodont faunas of both the carbonate and the clastic facies.

## B. Significance of Conodont Studies

Paleontological investigations of conodont faunas from the southern Mackenzie region are expected to contribute towards a better understanding of many of the specific aspects of conodont-related work, such as: conodont biostratigraphy (Sweet and Bergström, 1976; Tipnis et al., in press); conodont paleoecology (Barnes et al., 1973; Barnes, 1976, ed.; and Tipnis et al., 1975); conodont paleothermometry (Epstein et al., 1977); conodont provincialism and/or biogeography (Bergström, 1973; Lindström, 1976a).

## C. Conodonts in Western/Arctic Canada

Early and Middle Ordovician conodont faunas of western Canada are still largely undescribed and, as yet, there is little information on the geographic and stratigraphic distribution of Ordovician conodonts in the Cordilleran region available. The first published study was that of Ethington and Clark (1965), who described and illustrated some Early Ordovician conodonts from the section at the Columbia Icefields, Alberta. Oberg (1966) described a Midcontinent conodont fauna from the Winnipeg Formation, Manitoba. Subsequently, Derby et al. (1972) reported several conodont species that occur near the Cambro-Ordovician boundary at the Mount Wilson North section, and, based on a similar distribution of conodonts across this boundary in the western United States of America, proposed four faunal units that could be useful in recognizing Upper Cambrian to lowest Ordovician strata.

Later reports on conodonts were those of Barnes and Uyeno (in Barnes et al., 1974) and Uyeno (in Dean, 1973). They listed conodonts of Midcontinent and North Atlantic aspect from Ordovician strata of the

Northwest Territories and Yukon Territory, respectively.

The Ordovician conodont faunas of the Canadian Arctic Islands and Hudson Bay area are currently being investigated by Barnes and others, and some works on these faunas have already been published (Barnes and Munro, 1973; Barnes, 1974; Workum, Bolton and Barnes, 1976; Barnes, Nowlan and Mirza, 1976a; Barnes, 1977). Most of the Ordovician conodont taxa listed from this region are Midcontinent in aspect, although the late Middle and Late Ordovician collections include some elements of North Atlantic aspect.

Exploratory work by B.D.E. Chatterton in western Alberta, northeastern British Columbia and the southwestern District of Mackenzie has shown that conodonts of Midcontinent aspect predominate in strata deposited on the Early and Middle Ordovician continental shelf. Tipnis _et al_. (1975) reported the occurrence of both Midcontinent and North Atlantic element-dominated faunas from the southwestern District of Mackenzie, and pointed out the restriction of the North Atlantic taxa to strata deposited in deeper western shelf margin or continental slope environments. More recently, Tipnis _et al_. (in press) have illustrated many of the biostratigraphically significant taxa and documented their stratigraphic occurrences in the southern Mackenzie strata.

## D. Method of Study

### 1. Field Collections

This work is based on samples collected from fifteen stratigraphic sections measured during the period from 1971 to 1973 (mainly by R. Ludvigsen, but also partly by B.D.E. Chatterton). Because of the generally difficult terrain, access to the collecting localities was possible only with the help of helicopters. This naturally imposed some financial and physical constraint on the number and size of samples, as well as rendered impractical the possibility of recollecting. However, despite this, the material at hand is considered adequate for the nature of the study undertaken in this thesis.

The Ordovician stratigraphy of this region was discussed in detail by Ludvigsen (1975); and following Tipnis et al. (in press), I have used the same formational nomenclature. The measured sections referred to here are the same as those discussed in Ludvigsen (op. cit.) plus section J. Ludvigsen's letter and number designations are used with the addition of the number of meters above the base of the section to the end of his number (preceded by a colon). The location of the sections and some spot sample localities are shown in Text-figure 1.

## 2. Laboratory Methods

Approximately 305 samples were processed for conodonts, and over 9000 identifiable elements were recovered. Although almost 90 per cent of the samples contained conodonts, the number of elements within them varied considerably. The average yield per sample was between 15 and 20 elements. The samples were not of constant size (they ranged from approximately ½ kg to over 5 kg), but most were between 1 and 2 kg in weight.

The method of processing described by Collinson (1963) was followed. The residue finer than 60 mesh and coarser than 120 was searched for conodonts after concentrating with tetrabromoethane.

All of the types, figured specimens and fauna slides are to be placed in the Type G.S.C. Collection in Ottawa.

## E. Nature of the South Mackenzie Material

In general, the conodonts are well preserved but many tend to break on manipulation. High temperatures presumably accompanied times of stress and/or deep burial, for the conodonts vary from translucent to opaque and also vary through shades of dark grey to black (Epstein *et al*., 1977, CAI IV-V). Consequently, basal cavities are rarely distinguishable and lack of a description of the cavity implies that it could not be observed.

The opaque nature of the elements inhibits distinction of hyaline and nonhyaline elements, and morphological appearances are usually the only guide. It was felt unnecessary to provide information on the Colour Alteration Indices of individual collections, since the high indices of all collections examined suggested that this would prove to be of little practical value.

# CHAPTER II

# STRATIGRAPHY

## A. Introduction

The history of geological investigations into the south Mackenzie Mountain region goes back as far as 1910 [Keele (1910) in Gabrielse *et al*. (1973)]. However, after a large gap of over 40 years, attention was redirected to the region when Kingston (1951) described a thick and continuous sequence of Ordovician rocks along the South Nahanni River. He grouped these Ordovician rocks into the Sunblood Formation.

During the completion of Operation Mackenzie, areas adjacent to the south Mackenzie region were mapped and investigated (Douglas and Norris, 1960, 1961, 1963). This resulted in the establishment of the Whittaker Formation for the sequence of carbonates and shales that overlie the Sunblood Formation.

Work completed during Operation Nahanni was directed primarily towards investigating the geology of the south Mackenzie region. This study was responsible for establishing most of the present stratigraphic nomenclature of the region (summarized by Gabrielse *et al*., 1973).

During the 1960's several papers were published whose findings are all incorporated and discussed in Gabrielse *et al*. (1973), which must be considered as an excellent documentation of the geology of the region. While complete lists of all relevant references prior to 1970 are available in that work, two deserve specific mention, namely

Gabrielse (1967) and Norford et al. (1970). In the former paper, Gabrielse clearly recognized the three most important tectonic features of the region during the Ordovician, namely the Selwyn and Root basins (sites of deposition), and the Redstone Arch (a positive element that separated these basins and affected the sedimentation history of the area). Norford et al. (1970) speculated on the presence of a continuous Middle Ordovician sequence (Marmor to Maysvillian) in the south Mackenzie region.

Gabrielse et al. (1973) integrated much new stratigraphic data and established two new Formations, the Broken Skull and the Rabbitkettle formations. Incorporated into the former were all the carbonates that occurred below the Sunblood Formation; while in the latter case, the Rabbitkettle Formation consisted of well-bedded, massive, silty limestones and calcareous siltstones that occupied the western and southwestern parts of the study area. They also extended the applicability of the term Road River Formation (Jackson and Lenz, 1962) to similar-aged shales in parts of the Selwyn Basin.

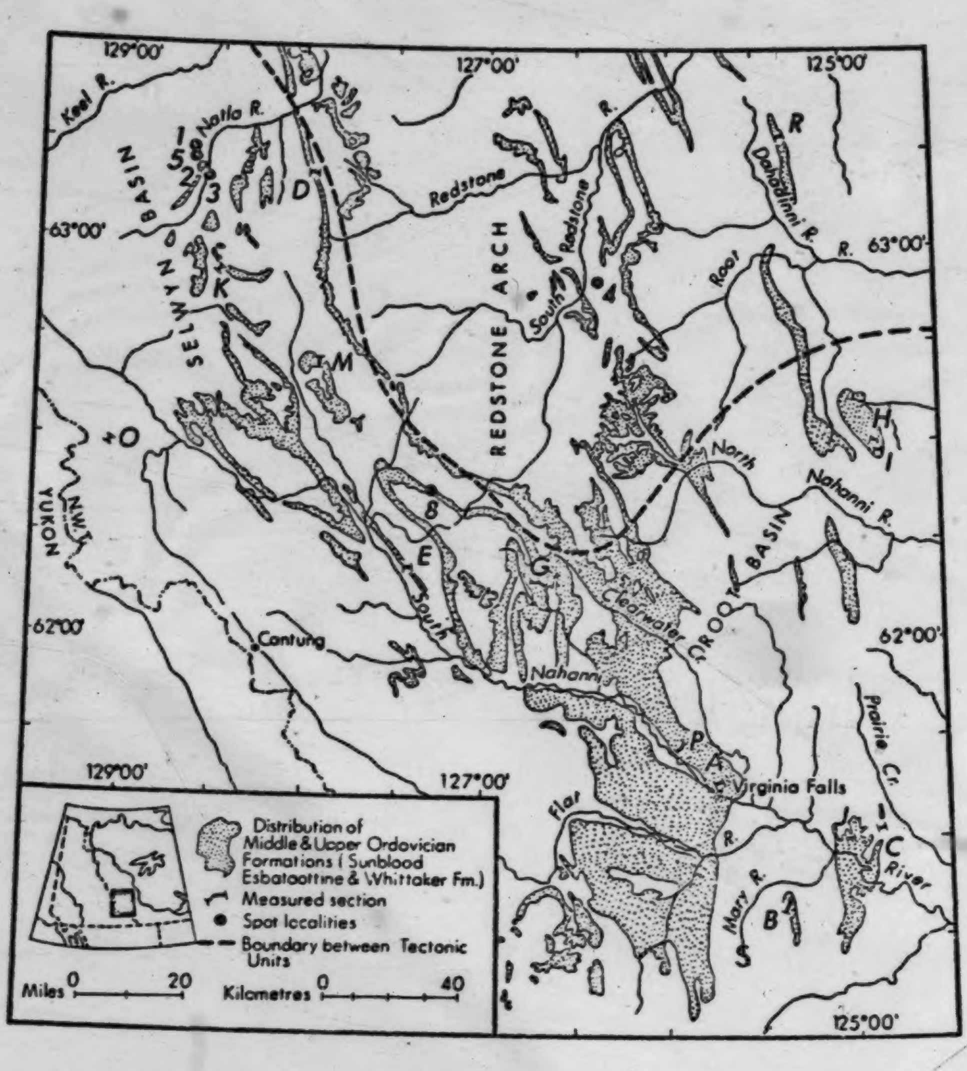
A considerable surge of geological activity took place in the region after 1970. Especially pertinent to the present study were the projects undertaken by Rolf Ludvigsen (then with the University of Western Ontario) and Brian Chatterton (University of Alberta). Ludvigsen's field studies comprised of samples from several measured sections, collected for both macrofaunas (trilobites and brachiopods) and microfaunas (conodonts, ostracodes). Similar collections, although on a somewhat smaller scale, were made by Brian Chatterton.

The first major study based on this new and detailed paleontological collection was that of Ludvigsen (1975). The study demonstrated

EXPLANATION OF TEXT-FIG. 1. Locality map of the South Nahanni River area showing measured sections (capital letters) and isolated collections (numbers). The outcrop areas of the Sunblood, Esbataottine, and Whittaker formations are indicated by stipple. Equivalent fine clastic rocks of the Road River Formation are not outlined. Based on Ludvigsen (1975). The following sections are shown:

| | |
|---|---|
| Sections A, P | Sunblood Range |
| Section B | Mary Range |
| Sections C, J | Funeral Range |
| Section D | Natla River East |
| Section E | Glacier Lake East |
| Section G | Flood Creek |
| Sections H, I, Q | Whittaker Range |
| Section K | Broken Skull North |
| Section M | Grizzly Bear Lake |
| Section O | Summit Lake |
| Section R | Dusky Range |
| Section S | Caribou Range |

Also shown are the locations of isolated collections which include Locs. 1-3 and Loc. 5 from various parts of the Selwyn Basin and Loc. 4 from the southern Mackenzie platform.


129°00'
127°00'
125°00'
Keel R.
Natla R.
BASIN
SELWYN
Redstone
REDSTONE ARCH
South Redstone
R.
Root
Dahadinni R.
63°00'
North
Nahanni R.
SELWYN
YUKON
N.W.T.
Clearwater
SELWYN BASIN
South
Nahanni
ROOT BASIN
Cantung
62°00'
Prairie Cr.
Virginia Falls
Flat
R.
Mary R.
River
1
2
3
4
5
B
C
D
E
G
H
K
M
O
P
R
Distribution of Middle & Upper Ordovician Formations ( Sunblood Esbataottine & Whittaker Fm.)
Measured section
Spot localities
Boundary between Tectonic Units
Miles 0 20
Kilometres 0 40

TEXT-FIGURE 1. Locality map of the study area.

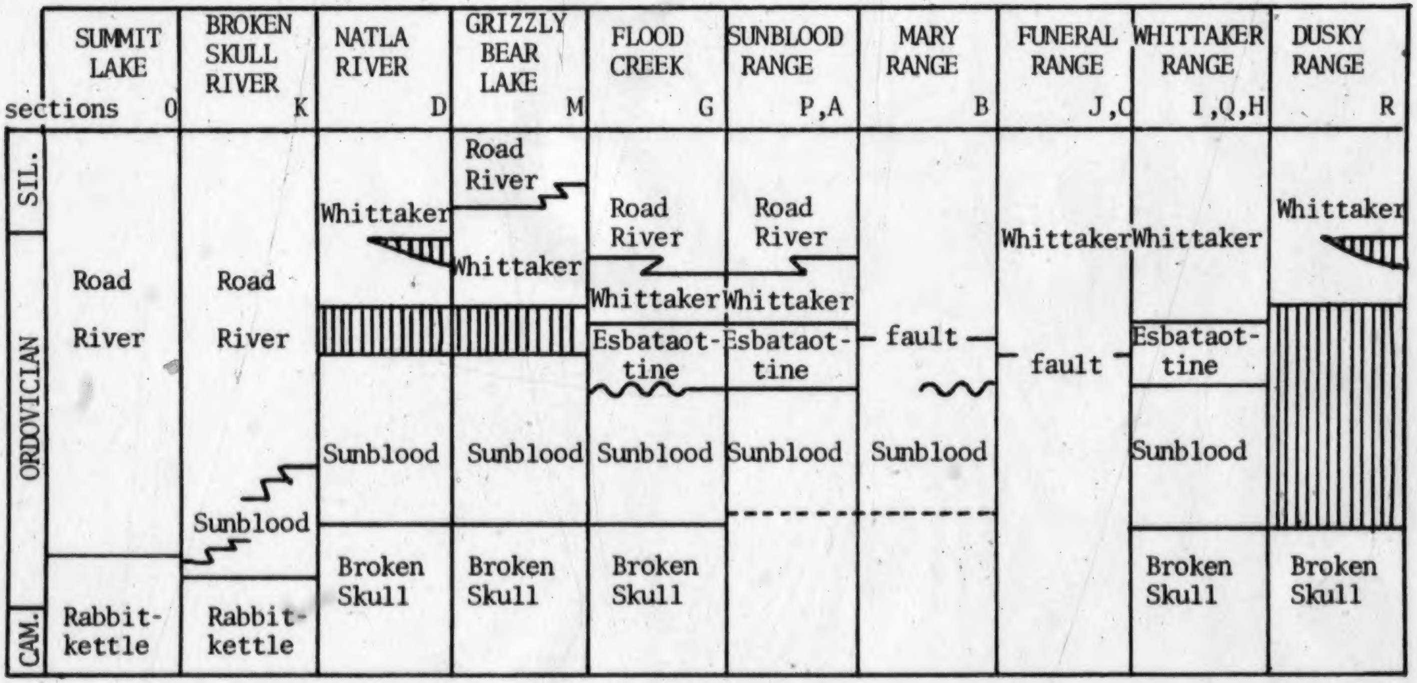
the general continuity of a late Canadian to Late Ordovician sequence; established a useful zonation scheme for the purpose of correlation and/or dating strata of this age in the region; pointed out the close faunal similarities with other regions of North America; and recognized the influence of ecology over distributional patterns within the Late Ordovician.

Ludvigsen also made some stratigraphic amendments and established a new formation, the Esbataottine Formation, that incorporated strata between the Sunblood Formation below and the Whittaker Formation above (see discussion in Stratigraphy for details).

Although there have been several additional publications following Ludvigsen (1975), none of them have attempted to either refine or revise the stratigraphy of the region.

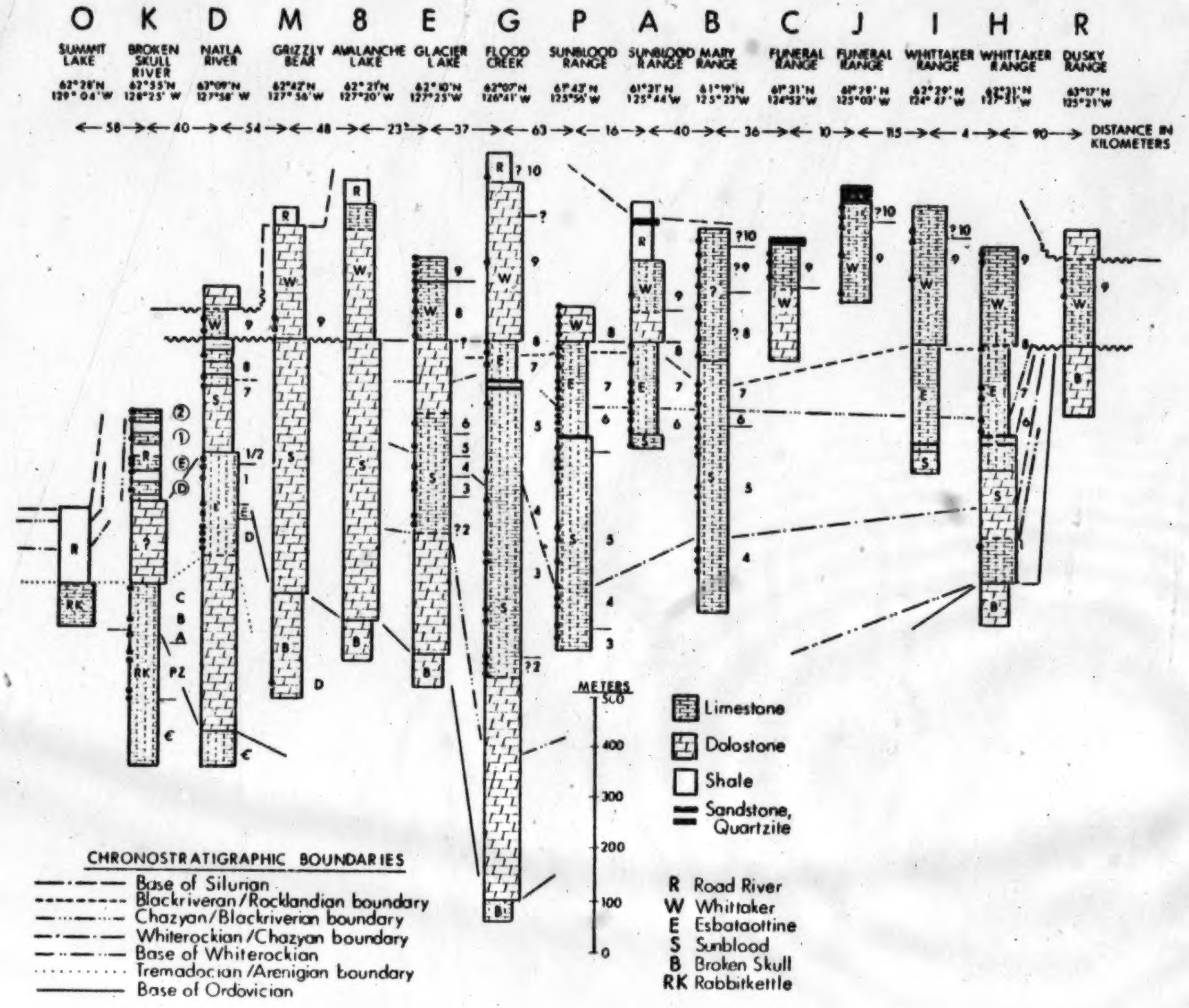
At present, the stratigraphic amendments registered by Ludvigsen (1975) appear to be accepted [Tipnis _et_ _al_., 1975; Chatterton and Ludvigsen, 1976; and Tipnis _et_ _al_., in press]. In my own treatment of the discussion on stratigraphy, I have followed Tipnis _et_ _al_. (in press).

The three most important tectonic elements that influenced the deposition of Ordovician strata in the study area, as noted earlier, were outlined by Gabrielse (1967). They consist of two depositional basins, the Selwyn and Roots basins, and a positive element, the Redstone Arch (Text-figure 1). Their influence over the sedimentation of this area was shown in more detail for various periods during the Ordovician by Ludvigsen (1975, fig. 10). During the Early Ordovician, the Selwyn Basin was a site of predominantly fine clastic sedimentation, and the Root Basin was a region of carbonate deposition. The clastic/


SUMMIT LAKE
BROKEN SKULL RIVER
NATLA RIVER
GRIZZLY BEAR LAKE
FLOOD CREEK
SUNBLOOD RANGE
MARY RANGE
FUNERAL RANGE
WHITTAKER RANGE
DUSKY RANGE
sections
0
K
D
M
G
P,A
B
J,C
I,Q,H
R
SIL.
ORDOVICIAN
CAM.
Road River
Rabbit-kettle
Road River
Sunblood
Rabbit-kettle
Whittaker
Sunblood
Broken Skull
Road River
Whittaker
Sunblood
Broken Skull
Road River
Whittaker
Esbataot-tine
Sunblood
Broken Skull
Road River
Whittaker
Esbataot-tine
Sunblood
fault
Sunblood
Whittaker
fault
Whittaker
Esbataot-tine
Sunblood
Broken Skull
Whittaker
Broken Skull

TEXT-FIG. 2. Diagram showing the distribution of the formations and the location of the sections. (Based in part on original provided by Ludvigsen in 1975.)

EXPLANATION OF TEXT-FIG. 3. Chart showing the distributions of formations, major lithologies and conodont faunal units (faunas of text) in 15 sections in the southwestern District of Mackenzie. The faunal units (letters and numbers beside the columns) are based on Miller (1975), Ethington and Clark (1971), and Sweet et al. (1971). PZ = Proconodontus Zone. A to E are Early Ordovician faunal units (Ethington and Clark, 1971). Numbers 1-10 are Middle to Late Ordovician faunal units (Sweet et al., 1971). Where collections consist predominantly of North Atlantic taxa, they are indicated by a circle surrounding the symbol for the Midcontinent faunal unit of equivalent age. (Based in part on original provided by Ludvigsen in 1975.)


O K D M 8 E G P A B C J I H R
SUMMIT LAKE 62°28'N 129°04'W
BROKEN SKULL RIVER 62°55'N 128°25'W
NATLA RIVER 63°09'N 127°58'W
GRIZZLY BEAR 62°42'N 127°56'W
AVALANCHE LAKE 62°21'N 127°20'W
GLACIER LAKE 62°10'N 127°25'W
FLOOD CREEK 62°07'N 126°41'W
SUNBLOOD RANGE 61°43'N 125°56'W
SUNBLOOD RANGE 61°31'N 125°44'W
MARY RANGE 61°19'N 125°23'W
FUNERAL RANGE 61°31'N 124°52'W
FUNERAL RANGE 61°29'N 125°03'W
WHITTAKER RANGE 62°29'N 124°47'W
WHITTAKER RANGE 62°31'N 127°31'W
DUSKY RANGE 63°17'N 125°21'W
←58→←40→←54→←48→←23→←37→←63→←16→←40→←36→←10→←115→←4→←90→ DISTANCE IN KILOMETERS
METERS
500
400
300
200
100
0
Limestone
Dolostone
Shale
Sandstone, Quartzite
R Road River
W Whittaker
E Esbataottine
S Sunblood
B Broken Skull
RK Rabbitkettle
CHRONOSTRATIGRAPHIC BOUNDARIES
Base of Silurian
Blackriveran/Rocklandian boundary
Chazyan/Blackriverian boundary
Whiterockian/Chazyan boundary
Base of Whiterockian
Tremadocian/Arenigian boundary
Base of Ordovician

carbonate facies boundary moved to the east during the Ordovician, particularly in the southern part of the study area. The Redstone Arch was apparently subaerially exposed for part of the Early and Middle Ordovician, and was the probable source of a thin sandstone unit occurring at the top of the Sunblood Formation in some sections (Ludvigsen, 1975).

Ludvigsen (1975) extended the application of the term Broken Skull Formation (Gabrielse _et al_., 1973) to include rocks on the east side of the Redstone Arch, and revised the two established Ordovician formations in the South Nahanni River area, the Sunblood Formation (Kingston, 1951) and the Whittaker Formation (Douglas and Norris, 1961) to accommodate his Esbataottine Formation. He followed Gabrielse _et al_. (1973) in retaining the name Road River Formation for the thick graptolitic shale sequence that forms the western fine clastic equivalent of the Ordovician carbonate formations and, in part, overlies the carbonate succession. The nomenclatural chart of the Ordovician formations of the region, as prepared by Ludvigsen (1975), is included for reference (Text-figure 2).

Text-figure 3 shows the distribution of the six formations considered, and their gross lithologies, in the fifteen sections discussed from the area. The stratigraphy and formational nomenclature is principally that of Ludvigsen (1975). The ages and correlations shown are based on information derived from the conodont faunas discussed here. Where collections can be confidently placed in a conodont zone or informal faunal unit, that zone is shown by a letter or number placed in the appropriate stratigraphic position on the right hand side of the schematic lithologic column, for the correct section.

## B. Rabbitkettle Formation

The Rabbitkettle Formation forms the lower part of the two westernmost sections (K and O) collected from the study area. No conodonts were obtained from Section O. In Section K, the Rabbitkettle Formation consists of limestones with minor interbedded silty limestones and siltstones. The thickness of this formation exceeds 1330 meters locally (Gabrielse et al., 1973). Section K includes only the upper 410 meters of the formation.

The Rabbitkettle Formation unconformably overlies Lower/Middle Cambrian strata and is in turn overlain by the Road River Formation in the Selwyn Basin (contact gradational to unconformable, Ludvigsen, 1975, p. 675). To the east, this formation or its facies equivalent, the Broken Skull Formation, is overlain (conformably to unconformably) by the Sunblood Formation (Gabrielse et al., 1973).

The Rabbitkettle Formation has not been dated with macrofossils. Trilobites belonging to the Upper Cambrian Saukia Zone, however, are present (Ludvigsen, personal communication, 1975). Gabrielse et al. (1973) implied that this formation is the same age as the adjacent Broken Skull Formation. This was based on lithostratigraphic criteria. However, detailed biostratigraphic work based on conodonts provides significant new data that allow for a more precise stratigraphic evaluation of this Formation.

The lower samples from the Broken Skull Formation at Section K (K270:82 to K390:119) yielded protoconodonts and paraconodonts of Late ?

Cambrian age, such as '*Furnishina*' and '*Hertzina*'. These horizons are overlain by strata bearing conodonts representative of the Late Cambrian *Proconodontus* Zone *sensu* Miller (1975) (K525:160, K715:218). A stratigraphically higher collection (K880:268) yielded taxa characteristic of the earliest Ordovician *Cordylodus proavus* Zone and the earliest Ordovician *Missisquoia* Zone. Still higher (K995:303), a sample contained conodont taxa that probably belong to the middle Tremadocian Fauna B of Ethington and Clark (1971). The youngest conodont-bearing sample from this formation (K1155:352) contains a few nondescript ramiform elements of probable middle to late Tremadocian age.

## C. Road River Formation

The Road River Formation was proposed by Jackson and Lenz (1962) for the thick sequence of graptolitic shales with thin interbeds of argillaceous limestone occurring in the northern Yukon Territory. In that area, this formation has a maximum age range of Tremadocian to at least early Emsian, although locally the age range may be considerably narrower. Gabrielse *et al*. (1973) applied this name to similar lithologic sequences occurring in the western part of the southern Mackenzie Mountains (Selwyn Basin). This formation unconformably overlies the Rabbitkettle in the westernmost part of the Flat River sheet (Blusson, 1968a,b). Further to the Northwest, however, it apparently lies conformably on top of the Rabbitkettle Formation (Section O, Ludvigsen, 1975). In Section K, the age information provided by the conodonts suggests that there is no major hiatus between this formation and the black dolostone unit that lies beneath it. Ludvigsen (1975) included this dolostone unit in the Sunblood Formation (suspecting an unconformity beneath it), but it could probably equally well be included in the Broken Skull Formation.

Nine samples collected through the lower part of the Road River Formation at Section K contained conodonts, but no macrofossils other than abundant inarticulate brachiopods. The conodont taxa in these samples are predominantly of the North Atlantic type. They are sparse in most of the samples with the exception of K2375:724, which contained a diverse collection of conodonts. The oldest sample (K1900:579) yielded some simple protopanderodid elements, together with *Oneotodus variabilis* Lindström s.f., *Drepanoistodus forceps* (Lindström) and *Acodus* n. sp. A. The five succeeding samples (K2020:616, K2050:625, K2090:637, K2145:654, K2200:671) yielded conodonts similar to those of the early and middle Arenigian faunas of the Baltic region. Still higher in the same sequence, near the top of the section (K2375:724), a collection of abundant and diverse conodonts was obtained. This contains many genera that are most common in the Middle Ordovician, and species that occur towards the base of the Middle Ordovician. The genera *Eoplacognathus*, *Protopanderodus* and *Periodon* occur together in this sample. Many of the elements of this collection are very similar to those described by Uyeno and Barnes (1970) from the Lévis Formation, Quebec, which would suggest a late Arenigian to early Llanvirnian (equivalent to Whiterockian) age for this horizon. A grab sample from the Road River Formation (Locality 5, see Text-fig. 1) yielded abundant conodonts of North Atlantic aspect belonging to the *Pygodus serrus* Zone, including the nominate species. Another sample (Locality 2, see Text-fig. 1) yielded a sparse fauna, that contained the important late

Caradoc species Amorphognathus superbus (Rhodes).

## D. Broken Skull Formation

This formation was proposed by Gabrielse et al. (1973, p. 45) for sequences of dolostones and limestones, whose lower parts are variably sandy, that occur above the Rockslide and Avalanche formations and below the Sunblood Formation in the central and eastern Glacier Lake map-area. In the western part of the study area, this formation grades laterally into the fine clastic facies of the Selwyn Basin, and into the Rabbitkettle Formation. The conodont faunas suggest that the upper part of the Broken Skull Formation is a time equivalent of the lower part of the Road River Formation in Section K. Most of the conodont collections from the Broken Skull Formation were obtained from one section (Section D, Natla River area) situated close to the western edge of the Ordovician shelf.

Collections obtained from the upper unit of this formation yielded well preserved and diverse conodont faunas. The sequential distribution of some Midcontinent conodonts in collections obtained from an upper Broken Skull limestone unit at Section D allows the recognition of Faunas D and E of Ethington and Clark (1971) and Fauna 1 (and Fauna 2?) of Sweet et al. (1971). North Atlantic conodonts present in these collections suggest an age of Latorpian to earliest Volkhovian (Lindström, 1971, p. 47, fig. 8). The Lower/Middle Ordovician (Canadian-Champlainian) boundary in Section D lies within and close to the top of the Broken Skull Formation (? as low as 90 m below top), within beds yielding the Hesperonomia Fauna which Ludvigsen (1975, p. 677) considered Canadian in age.

Conodont evidence suggests that the top of the Broken Skull Formation may be early Whiterockian in age.

## E. Sunblood Formation

The Sunblood Formation was proposed by Kingston (1951) for Ordovician rocks in the vicinity of Virginia Falls, South Nahanni River area. The formation has since been discussed and used by a number of workers, but has most recently been restricted by Gabrielse et al. (1973), who assigned parts of the Early Ordovician section of this region to the Broken Skull Formation; and by Ludvigsen (1975, fig. 2), who included the upper part of the Middle Ordovician strata and possibly some Upper Ordovician strata in the Esbataottine and Whittaker Formations, respectively. I have followed Ludvigsen in considering this formation to be restricted to generally resistant dolostones and red-orange-buff weathering limestones that occur above the Broken Skull Formation, and lie beneath, or are stratigraphic equivalents of, the Esbataottine Formation. Where the upper part of this formation is a facies equivalent of the Esbataottine Formation, it is overlain by the Whittaker Formation (Text-figs. 2 and 3). The top of the Sunblood Formation, in some sections close to the southern end of the Redstone Arch, is characterized by a thin sandstone or quartzite unit. The contacts between this formation and overlying units appear to be conformable.

A number of biostratigraphically useful conodont collections were obtained from limestone horizons within this formation. No conodonts were recovered from the lower dolostone unit. Faunas near the top of the Broken Skull Formation, and in the lower Sunblood Formation, are earliest Middle Ordovician in age (Fauna 1 of Sweet et al., 1971). Collections from limestones of the upper part of the Sunblood Formation have yielded conodonts of Midcontinent type and can be assigned to Faunas 3-6 of Sweet et al. (1971) (Whiterockian to upper Chazyan), correlations consistent with those of Copeland (1974) and Ludvigsen (1975), which were based on ostracodes, trilobites, and brachiopods.

The base of the upper limestone unit of the Sunblood Formation yielded conodont collections which contain elements most diagnostic of Fauna 3, but also contain some that are usually found in Fauna 2. Slightly higher, elements that are typical of Fauna 3 are present in large numbers. These collections are dominated by multielement species of Multioistodus, and the fauna is similar to that described by Mound (1965) from the Joins Formation of Oklahoma. The change in the fauna from collections containing elements of both Faunas 2 and 3 to those dominated by elements characteristic of Fauna 3 alone can be recognized in both sections E (Glacier Lake) and G (Flood Creek), so that one can correlate this part of the Sunblood Formation accurately between these sections.

Collections that can be assigned to Fauna 4 occur slightly higher in sections B, E, G and P. These late Whiterockian collections are quite distinct and contain several elements belonging to the two multielemental taxa "Phragmodus" n. sp. A and "Eoneoprioniodus" n. sp. A

Three collections from the Mary Range, Section B (B700:213, B795:241 and B860:261), yielded a new species of Oulodus, Oulodus n. sp. A, which appears to be restricted to Fauna 5.

Collections from the upper, but not uppermost, part of the limestone unit at sections B, G and P yield conodonts typical of Fauna 5, of early Chazyan age (Sweet *et al*., 1971). *Phragmodus flexuosus* Moskalenko (= *Phragmodus* sp. A of Sweet *et al*., 1971), the index species of this faunal unit, is present in collections from these three sections.

A conodont collection at the top of the Sunblood Formation at Section P (P1405:428) includes a number of specimens of *Chirognathus*, together with other fibrous elements belonging to the genera *Curtognathus* and *Erismodus*. Several workers have suggested that faunas of this type are diagnostic of shallow water environments (Barnes and Fåhraeus, 1975; Tipnis *et al*., 1975). The genus *Chirognathus* makes its first appearance in Fauna 6 (Sweet *et al*., 1971), although it is more characteristic of Fauna 7.

In one section, section B in the Mary Range, typical Sunblood lithologies persist into younger rocks than at the type section of the Sunblood Formation at Sunblood Mountain. This portion of section B is correlative with the Esbataottine and lower Whittaker formations, and, in Text-fig. 3, these rocks have been assigned to the Sunblood Formation, with a query.

### F. Esbataottine Formation

The Esbataottine Formation was proposed by Ludvigsen (1975, p. 669) for a series of moderately recessive, grey-to-buff coloured, thinly bedded limestones that occur between the Sunblood and Whittaker formations. It often overlies a thin quartzite unit at the top of the Sunblood Formation. The top and bottom of this formation are conformable with both the Whittaker and Sunblood formations. The top of the Esbataottine Formation is placed at a horizon where comparatively recessive limestones are replaced by the first occurrence of medium crystalline and medium-to-thick bedded dolostones of the Whittaker Formation. Conodont collections were obtained from sections G, A, P and H, in the Esbataottine Formation. The formation ranges in thickness in these sections from approximately 79 meters (section G) to about 190 meters (in Sunblood and Whittaker Ranges, sections A, P, H).

In section P, collections from the lower part of the Esbataottine Formation (P1485:453 - P1540:469) contain a number of new taxa, including Phragmodus flexuosus symmetricus Tipnis et al. (in press). This subspecies may be a useful index fossil for Fauna 6 and also occurs in some samples from approximately the same stratigraphic position in section A (A 110:34 - A190:58); and in section H (H820:250). Thus, the lower part of the Esbataottine Formation is included in Fauna 6.

Fauna 7 makes its first appearance just below the middle of the Esbataottine Formation in several sections (A, P, G, H), and in the upper part of the Sunblood Formation where the Esbataottine Formation has not been recognized (sections D and B). This Blackriveran faunal unit (Fauna 7) is recognized in the study area on the basis of the occurrence of Plectodina aculeata (Stauffer) and Oistodus nevadensis Ethington and Schumacher s.f. (see further discussion under Biostratigraphy). Two samples from section P (P1665:507, P1730:527) also contained the index species of Fauna 7, Phragmodus inflexus Stauffer. This faunal unit ranges up to an horizon near the top of the Esbataottine Formation, where it is usually replaced by Fauna 8.

Fauna 8, which is considered to be Rocklandian in age, is represented by a few samples near the top of the Esbataottine Formation in sections A and P. I have recognized this faunal unit primarily on the occurrence of *Phragmodus undatus* Branson and Mehl, below the first occurrence of *Plectodina furcata* (Hinde) and *Aphelognathus kimmswickensis* Sweet *et al*. The Esbataottine Formation may therefore be dated as late Chazyan to Rocklandian on its conodont faunas. Copeland (1974) dated this interval as Porterfieldian and Wildernessian, based on its ostracode faunas; and Ludvigsen (1975) as Chazyan and Blackriveran, based on its trilobite and brachiopod faunas.

### G. Whittaker Formation

The Whittaker Formation was proposed by Douglas and Norris (1961, p. 7) for the thick sequence of grey weathering limestones, dolostones and shales that overlies the Sunblood Formation. They designated the east flank of the Whittaker Range as the type section. Douglas and Norris (*op. cit.*) subdivided the formation into three units in the Whittaker Range: a lower unit of limestone (402 meters - 1320 feet); a middle unit of dolostone (262 meters - 860 feet); and an upper unit of argillaceous limestone with minor siltstone (576 meters - 1890 feet).

The upper unit was assigned a late Early to early Late Silurian age by O'Bertos and Jackson (1963). The lower and middle units were dated as Late Ordovician by Douglas and Norris (1961). Ludvigsen (1975, p. 670) assigned parts of the lower unit to the Esbataottine Formation and considered the remaining parts of the lower and middle units to be Trentonian to early Late Ordovician in age. Copeland (1974) assigned the lower Whittaker Formation ostracode to a widespread Wilderness-Barneveld interval.

Ludvigsen (1975) pointed out that the distribution and composition of the brachiopod and trilobite faunas in this formation are closely controlled by lithofacies. The conodonts may also have been controlled by environmental parameters that probably affected the distribution of the lithofacies. Conodont collections from sections close to the Ordovician shelf margin (sections D, E, and M) generally contain more specimens than those from the shelf proper, further to the east (sections B, C, I, J, P and R). Three spot samples from the Selwyn Basin (Locs. 1, 2, 3) and one collection from the Root Basin (Loc. 4), from horizons in the Road River Formation of similar age, contained faunas of relatively low diversity that are dominated by taxa characteristic of deeper water slope facies (*Periodon*, panderodids and protopanderodids); and that are different from the taxa characteristic of the shelf facies. Locality 2 also yielded *Amorphognathus*.

Comparatively few diagnostic taxa are present in the collections obtained from the Whittaker Formation. *Phragmodus undatus* Branson and Mehl and *Plectodina furcata* (Hinde) occur in some of the collections (the latter form being diagnostic of Fauna 9 or younger). *P. furcata* makes its first appearance somewhat above the base of this formation, except in some sections where Ludvigsen (1975) postulated that the Whittaker Formation lies unconformably on top of the Sunblood Formation, and where it contains the *Bighornia-Thaerodonta* Fauna at its base. In these sections (sections D and M), this species occurs closer to the base of the formation. Thus, the lower part of Whittaker Formation is possibly Rocklandian in age (Fauna 8) in those sections where the Whittaker Formation lies conformably on top of the Sunblood or Esbataottine formations, but it can be demonstrated to be at least as young as Fauna 9 in those sections where the lower contact is probably disconformable.

It is difficult to use the conodont taxa present in the collections from the southern District of Mackenzie to identify Fauna 10 (and even possibly younger horizons) with any degree of certainty because many of the taxa are long-ranging. The highest parts of the Whittaker Formation collected are probably Late Ordovician in age, although there is no evidence to suggest that they are younger than early Late Ordovician (Fauna 10) (in some regions, the Whittaker Formation is known to extend well up into the Silurian).

# CHAPTER III

## BIOSTRATIGRAPHY

### A. Introduction

#### 1. Ordovician Correlation

Beginning with Twenhofel et al. (1954), a number of workers have attempted to resolve or rectify the problems of Ordovician correlation. No early solution is anticipated as not enough is known about Ordovician provincialism (Bergström, 1973) and Ordovician paleoecology (Lindström, (1976a), and recent thoughts on this subject (Bassett, ed., 1976) clearly indicate that the situation may get worse before getting better [see Cooper (1976) and Bergström in Cooper (op. cit.) for opposing views]. The problem probably stems from the excessively partial views of individuals working on particular groups of fossils of their own interest. Based on the evidence available in the literature, one may argue about the superiority of one group over others. No fossil group is completely excluded from environmental influences and none has been demonstrated to have evolved rapidly and uniformly in space and time. These, together with the imperfections of the fossil record, prevent us from arriving at anything better than an approximation of the truth. All these pitfalls are familiar to biostratigraphers. Hence it is of some interest to note the growing body of Ordovician workers who have begun to use conodonts as amongst the most reliable 'time clocks' when discussing their stratigraphic data [see Ross (1976) and Barnes et al.

(1976)].

Ordovician conodont biostratigraphy has benefited considerably from four papers, namely those by Ethington and Clark (1971), Sweet, Ethington and Barnes (1971), Bergström (1971) and Lindström (1971) that appeared in Geological Society of America Memoir 127 (edited by Sweet and Bergström, 1971). Biostratigraphic schemes provided in these studies have been well tested in the past few years, and although some additional refinements are necessary, I believe one can safely predict that these will form an important base for Ordovician biostratigraphic studies of the future. (The presence of two schemes each instead of one for the Lower Ordovician and one for the Middle/Upper Ordovician is a result partly of separate work and partly of the existence of at least two separate faunal provinces during this period.)

The southern Mackenzie collections provide numerous opportunities to test all four of these schemes. Lower Ordovician schemes for the North American (Midcontinent) faunas (Ethington and Clark, 1971) occur at two levels, one low in the sequence (Faunas A, ? B) and the other at higher levels (Faunas D and E). The Lower Ordovician scheme of Lindström (1971) is represented at the level of *Oepikodus evae* Zone. The Middle/Upper Ordovician scheme for the North Atlantic type conodonts is also represented at two levels (*Pygodus serrus* Zone and *Amorphognathus superbus* Zone), while another taxon of possible zonal significance, *Eoplacognathus planus* (Sergeeva), occurs 120 meters above the *Oepikodus evae* Zone.

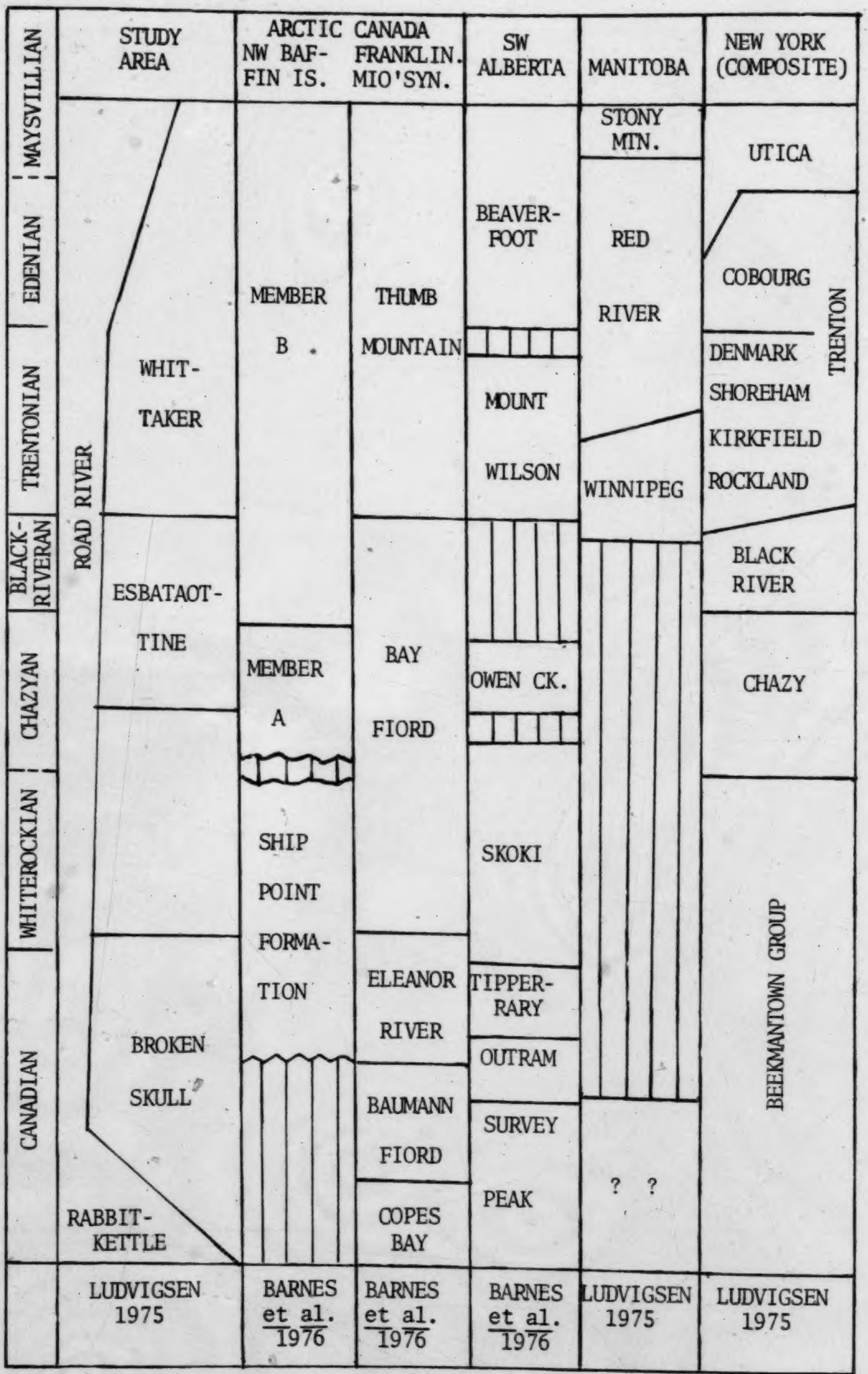
However, the most biostratigraphically useful collections are from the Middle Ordovician carbonates of the southern Mackenzie Platform which contain, in the same order of superposition, all the faunal units of Sweet et al. (1971) (Faunas 1-9, ? 10), with the possible exception of Fauna 2.

Text-figure 3 illustrates the biostratigraphic correlations suggested between various formations in the area studied. The diagram is based on Tipnis et al. (in press), and is modified after Ludvigsen (1975). Text-figure 4 is an attempt to correlate the Ordovician of the southern Mackenzie Mountains region with some well studied coeval sections from western and Arctic Canada. Most of the data incorporated in this diagram come from Barnes et al. (1976) and Ludvigsen (1975). Text-figure 5 shows the ranges of diagnostic Middle Ordovician Midcontinent species from the carbonates of southern Mackenzie platform. Text-figure 6 shows the occurrence of important zonal taxa from the Selwyn Basin and their localities.

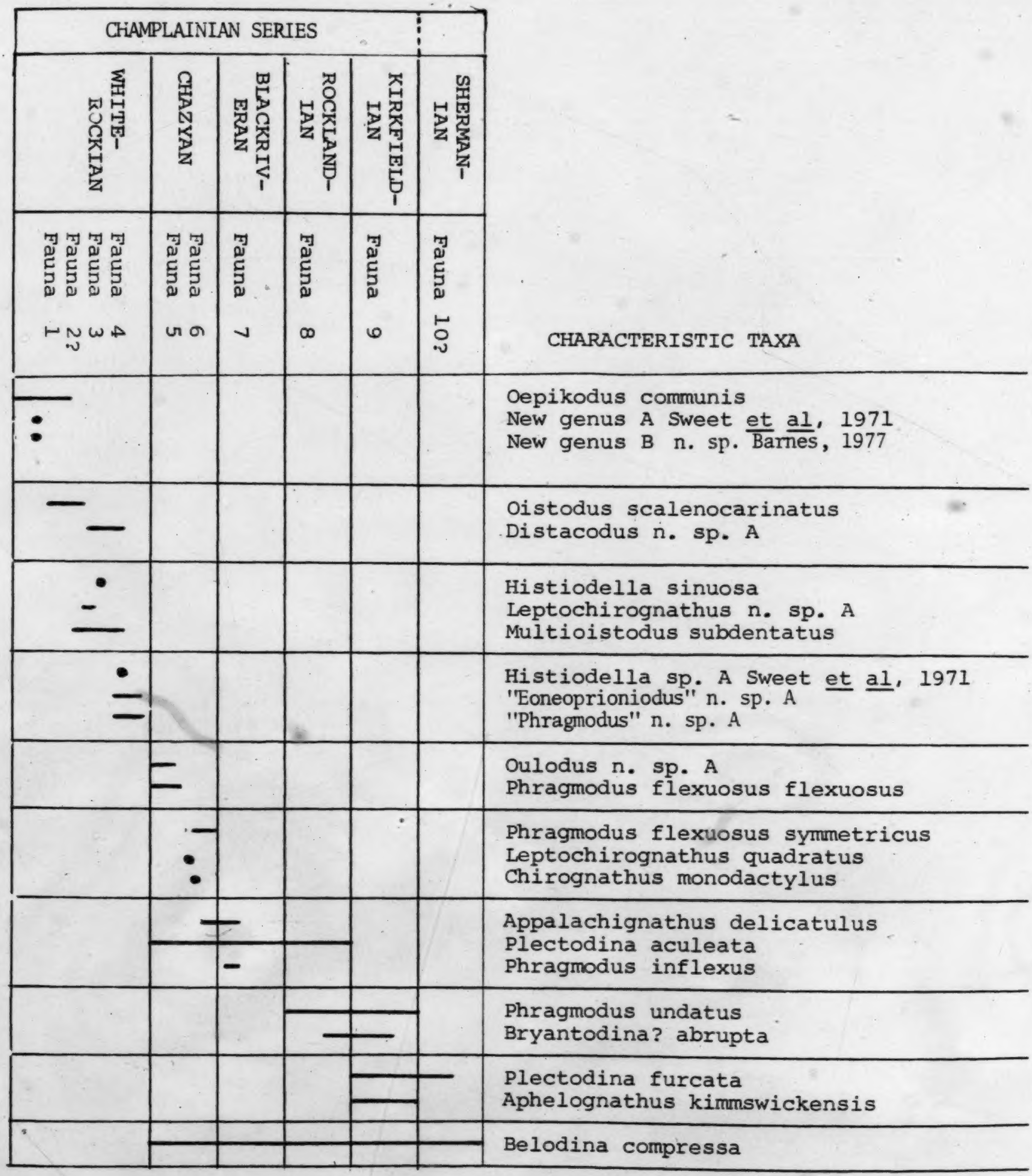
Tables I - XIV show the occurrences of conodont species through various stratigraphic levels of the study area.

## B. Distribution of Conodont Faunas (Lower and Middle Ordovician) from the Carbonate Facies

Late Canadian conodonts representing Faunas D and E of Ethington and Clark (1971) and early Whiterockian conodonts of Faunas 1 and ? 2 (Sweet et al., 1971) were collected from the Broken Skull Formation at Locality D. Conodonts from the lower part of this section (D215:66 to D555:169) contain relatively rare elements of Midcontinent type (similar to those reported from the Fillmore Limestone, Great Basin, and the El Paso Group, Marathon Basin) and several of the North Atlantic aspect [similar to elements from the Ninemile Formation, Great Basin (Ethington, 1972), Deep Kill Formation, eastern New York (Landing, EXPLANATION OF TEXT-FIG. 4. Diagram showing the correlation of Ordovician strata of the study area with Ordovician strata of arctic and western Canada. Vertical shading represents erosion or non-deposition; wavy line represents disconformity. Mio'syn. short for Miogeosyncline.


MAYSVILLIAN
EDENIAN
TRENTONIAN
BLACK-RIVERAN
CHAZYAN
WHITEROCKIAN
CANADIAN
STUDY AREA
ROAD RIVER
WHIT-TAKER
ESBATAOT-TINE
BROKEN SKULL
RABBIT-KETTLE
LUDVIGSEN 1975
ARCTIC CANADA
NW BAF-FIN IS.
FRANKLIN. MIO'SYN.
MEMBER B
MEMBER A
SHIP POINT FORMA-TION
BARNES et al. 1976
THUMB MOUNTAIN
BAY FIORD
ELEANOR RIVER
BAUMANN FIORD
COPES BAY
BARNES et al. 1976
SW ALBERTA
BEAVER-FOOT
MOUNT WILSON
OWEN CK.
SKOKI
TIPPER-RARY
OUTRAM
SURVEY PEAK
BARNES et al. 1976
MANITOBA
STONY MTN.
RED RIVER
WINNIPEG
? ?
LUDVIGSEN 1975
NEW YORK (COMPOSITE)
UTICA
COBOURG
DENMARK
SHOREHAM
KIRKFIELD
ROCKLAND
TRENTON
BLACK RIVER
CHAZY
BEEKMANTOWN GROUP
LUDVIGSEN 1975

TEXT-FIG. 4



TEXT-FIG. 5 Diagram showing the distribution of biostratigraphically significant conodont taxa in the Middle Ordovician carbonates of the southern Mackenzie platform.

EXPLANATION OF TEXT-FIG. 6. Chart showing suggested correlations between Ordovician series and North American stages, North American Midcontinent conodont faunal units, and some North Atlantic conodont zones present in the study area. The approximate positions of collections from the study area that contain biostratigraphically significant North Atlantic zonal taxa are shown separately. The relationships between the stages and the North Atlantic conodont zones are from Sweet and Bergström (1976); and the relationships between the North American series and conodont faunal units are from Ethington and Clark (1971) and Sweet *et al*. (1971). The samples from Loc. 2, Loc. 5, and K2375 contain mixtures of Midcontinent and North Atlantic taxa that support the correlations shown at their levels.

| BRITISH SERIES | NORTH AMERICAN SERIES | NORTH AMERICAN STAGES | CONODONTS | | IMPORTANT SAMPLES FROM SELWYN BASIN |
|---|---|---|---|---|---|
| | | | MIDCONTINENT FAUNAS | NORTH ATLANTIC ZONES | |
| CARADOCIAN | | EDENIAN | 11 ? | Amorphognathus superbus | LOC. 2 |
| | | | 10 ? | | |
| | CHAMPLAINIAN | SHERMANIAN | | | |
| | | KIRKFIELDIAN | 9 | | |
| | | ROCKLANDIAN | 8 | | |
| | | BLACKRIVERAN | 7 | | |
| | | ? | 6 | | |
| LLANDEILIAN | | CHAZYAN | | | |
| | | | 5 | Pygodus serrus | LOC. 5 |
| LLANVIRNIAN | | WHITEROCKIAN | 4<br>3<br>2 | \| | |
| ARENIGIAN | | | 1 | Eoplacognathus variabilis | K2375 |
| | CANADIAN | CANADIAN | E<br>D<br>-<br>B ? | Oepikodus evae | K2020 |
| TREMADOCIAN | | | A | | K860 |

TEXT-FIG. 6

1976), and the Arenigian faunas of the Hunneberg and Billingen Substages of the Baltic region]. The collections from the upper part (D615:187 to D860:262), however, are predominantly of the Midcontinent type.

Samples D215:66 to D288:88 contain such components of Fauna D as *Juanognathus jaanussoni* Serpagli, *Scolopodus rex* Lindström *sensu* Serpagli, *Scolopodus gracilis* Ethington and Clark, and *Drepanoistodus forceps* (Lindström). Possible North Atlantic taxa present in these samples are: *Drepanodus arcuatus* Pander *sensu* Lindström (1971); *Paroistodus amoenus* (Lindström); *P. parallelus* (Pander) and *Walliserodus* sp. aff. *W. australis* Serpagli . These collections can be assigned to Fauna D of Ethington and Clark (1971), or to the lower Latorpian Hunneberg Substage (BIα) of the Baltic region.

In the next two collections (D375:114 and D420:128) the scolopodids become particularly abundant (especially *S. rex*) while three important taxa, *Acodus deltatus deltatus* Lindström, *Drepanoistodus conulatus* (Lindström) and *Triangulodus* n. sp. A make their appearances.

Higher up in section D, one sample (D450:137) yielded elements characteristic of Fauna E [*Oepikodus communis* (Ethington and Clark) and *Oistodus lanceolatus* Pander]. In addition to these, the sample also contained numerous specimens of *A. deltatus deltatus*, *D. conulatus* and *Triangulodus* n. sp. A. These latter species are most abundant between D375:114 and D555:169, and are dated as belonging to the Billingen Substage (BIα) of the Latorpian Stage (BI) in Sweden (Lindström, 1955, 1971; Van Wamel, 1974). Most of the taxa listed here are also found in the Ninemile Formation of the Great Basin (Ethington, 1972), the Deep Kill Formation, eastern New York (Landing, 1976), and in the

Emanuel Formation of the Amsden Basin, Western Australia (McTavish, 1973).

The next higher sample, D555:169, yielded abundant conodonts together with the non-conodont hook-shaped phosphatic microfossil, *Ptiloncodus simplex* Harris, a species of *Westergaardodina*? and *Milaculum perforatum* Müller. As noted in Tipnis *et al*. (in press), *P*. *simplex* is not known to range below Fauna 1, while the problematic phosphatic microfossil *M*. *perforatum* was described and illustrated by Ethington and Clark (1965), as Form B, from the Skoki Formation of southern Alberta (included by Sweet *et al*., 1971, in Fauna 1). *P*. *simplex* and *M*. *perforatum* occur with New Genus A of Sweet *et al*. (1971) in the lower Skoki Formation. Also present in this collection are thin-walled, hollow conical-to-triangular structures with and without serrated margins that resemble somewhat the genera *Coelocerodontus* Ethington and *Stolodus* Lindström (New Genus New Species B and New Genus New Species C). Additional conodont taxa include *Paroistodus parallelus* (Pander), *Acodus deltatus deltatus* and *Stolodus* sp. aff. *S*. *stola* (Lindström).

Elements of *Oepikodus communis* (Ethington and Clark) reappear in section D in samples of earliest Middle Ordovician age (D790:241, D825:251, D840:256 and D860:262). This interval also contains several elements that are known to occur near the upper Canadian-Whiterockian boundary. Elements of Fauna 1 were identified from the following collections: D750:229, D790:241, D810:247 and D825:251. Elements normally diagnostic of Fauna 1, recognized in these collections, include: *Juanognathus variabilis* Serpagli, *Drepanoistodus conulatus* (Lindström), *Oistodus lanceolatus* Pander, *Triangulodus robustus* (Serpagli) and robust elements of *Paroistodus parallelus* (Pander) and *Drepanoistodus* basiovalis (Sergeeva).

Conodonts commonly found in Fauna 2 appear in the next two collections, D840:256 and D860:262. These include Oistodus scalenocarinatus Mound and Eoneoprioniodus spp. They are accompanied by O. communis, thereby suggesting a position near the base of Fauna 2. The continued presence of O. communis through almost 70 meters of strata (D790:241 to D860:262) appears to confirm the reported occurrence of this species in the lower part of Fauna 2 (Middle Ordovician) (Sweet et al., 1971).

## Fauna 1

Characteristic elements of Fauna 1 occupy a level near the base of the Middle Ordovician, and have been recognized as such near the base of the type Whiterock (Antelope Valley Formation, central Nevada). The fauna was first described from the Ibex section of western Utah, where it occurs in the upper Wahwah to lower Juab formations (Sweet et al., 1971).

In the southern Mackenzie Mountains, the characteristic elements of this fauna have only been found in collection H0:0, from the lower part of the Sunblood Formation. New Genus A of Sweet et al., 1971 and New Genus B of Barnes, 1977 (= New Genus B of Sweet et al., 1971), the diagnostic elements of this fauna, occur here. Numerous elements of Juanognathus variabilis Serpagli are also present.

Elements of Fauna 1 have been reported from the upper Eleanor River Formation, Devon Island, Canadian Arctic (Barnes, 1974); the top of the lower Skoki Formation of southern Alberta (Ethington and Clark, 1965; samples 50-53); and the El Paso Formation of Texas (Repetski, 1974).

## Fauna 2?

Some difficulty is noted in recognizing Fauna 2 since none of the characteristic components of this fauna, as listed by Sweet *et al*. (1971), are completely restricted to it. From horizons that probably belong to this faunal unit, a few distaconodontids, identified in this study as *Eoneoprioniodus* spp.      , were recovered at the base of a limestone unit of the Sunblood Formation that overlies an unfossiliferous dolostone unit in sections E and G. In section G (G1137:343), these forms are accompanied by isolated specimens of *Multioistodus subdentatus* Cullison, a species that becomes abundant in higher rocks designated to Fauna 3. In section E (E1030:314), these elements are accompanied by *Prioniodus* sp. 2 along with a specimen of *Multioistodus subdentatus*.

## Fauna 3

Sweet *et al*. (1976) recognized Fauna 3 on the basis of the appearance of *Multioistodus subdentatus* Cullison, together with *Histiodella sinuosa* (Graves and Ellison) s.f. Both of these forms have been recovered from the Mackenzie Mountains. The latter species was found in a collection from the Caribou Range (section S) southeast of the study area, made available to me in late 1976 by Rolf Ludvigsen. The most distinguishing character of Fauna 3 is the predominance of *Multioistodus subdentatus*.

*M. subdentatus* is abundant in several collections from sections E and G (E1155:352; E1245:379; E1445:456; G1235:376; G1425:434; G1760:536; G1825:556; G1850:564). Samples from the lower part of Fauna 3 in these sections contain two new multielemental taxa, *Leptochirognathus* n. sp.

A and New Genus New Species D. These forms may become important index species for the lower part of this faunal unit. Equivalents of Fauna 3 are best known from the Joins Formation of Oklahoma (Mound, 1965 ), and to some extent the Fort Peña Formation of the Marathon Basin, Texas (Bradshaw, 1969). Barnes (1974) listed conodonts of this age from the upper Ship Point Formation in the Canadian Arctic.

### Fauna 4

A number of collections containing rich and well preserved faunas represent this fauna from sections B and P (and a few collections from sections E and G). Fauna 4 has been recognized primarily on the basis of the occurrence of hyaline prioniodids. Most of these taxa are yet to be formalized and given names at the species level. They include the following form genera: *Prioniodus*, *Cordylodus*, *Cyrtoniodus*, *Subcordylodus*, "*Phragmodus*", *Dichognathus*, and *Erismodus*. Many of these are characteristic of younger Chazyan faunas where they form components of several important multielement species (e.g. *Phragmodus undatus* includes *Dichognathus typica* s.f., *Oistodus abundans* s.f., *Dichognathus brevis* s.f. and *Phragmodus undatus* s.f.). Elements of the genera noted above are usually of constant size, robust appearance, and tend to occur repeatedly with one another. I believe that they can be grouped into at least two apparatuses: 1) "*Eoneoprioniodus*" n. sp. A, which includes prioniodiform, prioniodiniform and tetraprioniodiform elements; and 2) "*Phragmodus*" n. sp. A, which includes cordylodiform, cyrtoniodiform, dichognathiform and ?phragmodiform elements. A distinctive prioniodiniform element (of somewhat erismodid profile) and referred to as '*Erismodus*' n. sp. 1 s.f. is another diagnostic taxon of this fauna. Also present in one collection (B310:94 ) is a denticulate species of Histiodella, probably Histiodella sp. A of Sweet et al. (1971).

Elements of Fauna 4 are known from the Whiterock Stage of western Utah and central Nevada (Sweet et al., 1971; Ethington, 1977; and Bergström, 1977a); the Joins and Oil Creek formations of Oklahoma (Sweet et al., 1971); the upper Ship Point Formation, Canadian Arctic (Barnes, 1974); and from eugeosynclinal rocks of the Tröndheim region (Norwegian Caledonides, Bergström, 1977a).

## Fauna 5

The distinction between Fauna 5 and Fauna 6 is not clear. Sweet et al. (1971) noted that Phragmodus flexuosus Moskalenko (Phragmodus sp. A of Sweet et al., 1971) ranges throughout the Chazyan; and suggested that Multioistodus subdentatus Cullison s.f. is essentially restricted to, and characteristic of, Fauna 5. MacHargue (1974), however, has pointed out that M. subdentatus probably extends downwards to the base of the Joins Formation, and therefore is not of much use stratigraphically. Other fibrous species, belonging to Erismodus and Curtognathus, are abundant in collections representative of Fauna 5 but they range well into Fauna 7. Moreover, Fauna 6 cannot be identified on the basis of the occurrence of any single species or genus. In an unpublished thesis on the type Chazy, Raring (1972) noted that the phragmodiform element of Phragmodus flexuosus (Phragmodus tortus of Raring (1972) underwent a gradual transformation from a slightly sinuous, asymmetric and somewhat robust element at the base of the Chazy to a less sinuous, more symmetrical and more compressed form in strata included in Fauna 6. Similar changes occur in forms through this part of the column in the southern Mackenzie Mountains. Tipnis et al. (in press) have used the latter form, their new subspecies Phragmodus flexuosus symmetricus, to distinguish Fauna 6; and considered P. flexuosus flexuosus to be restricted to Fauna 5.

All elements of Phragmodus flexuosus Moskalenko occur in association in a number of the collections of Chazyan age from sections B, G and P. Three of the collections from section B (B700:213; B795:242; B860:262) also contain a new Oulodus species, Oulodus n. sp. A, which I believe to be restricted to Fauna 5, while two collections contain elements of Rhipidognathus n. sp. A, a taxon also (?) restricted to Fauna 5.

Elements of Plectodina aculeata (Stauffer) are common in some collections assigned to Fauna 5 (Raring, 1972, found this species to be common throughout the type Chazy). Sweet et al. (1971) previously suggested that this species occurs first in Fauna 7. Several collections assigned to Fauna 5 contain fibrous elements, including: Curtognathus typus Branson and Mehl, Erismodus spp. and Polycaulodus bidentatus Branson and Mehl. Also present are a number of forms described from the Siberian Platform by Moskalenko (1973), including one that resembles "Ptiloconus?" strachanognathoides Moskalenko.

At present, collections representative of Fauna 5 have only been recovered from the upper limestone unit of the Sunblood Formation.

## Fauna 6

As noted above, this fauna is primarily recognized on the basis of the occurrence of Phragmodus flexuosus symmetricus, a new subspecies of Tipnis et al. (in press).

Some upper Chazyan collections from the Mackenzie Mountains are dominated by fibrous forms, and they contain rare elements of Phragmodus and few elements of Plectodina. In one such collection from section P, about 50 meters below the first occurrence of P. flexuosus symmetricus, and coincident with the base of the Esbataottine Formation, a fibrous fauna dominated by Chirognathus, Curtognathus and Erismodus is present. Another slightly older (?) collection from 70 meters below the top of the Sunblood Formation at section A (A100:30) is dominated by several robust elements of Leptochirognathus and contains a few lamellar elements belonging to Plectodina and Drepanodus. This fauna is very similar to that of the McLish Formation of Oklahoma, described by Branson and Mehl (1943), and included by Sweet et al. (1971) in Fauna 6. The presence of collections dominated by fibrous elements near the top of the Sunblood Formation suggests a shallowing or local regression at this horizon (Tipnis et al., 1975), an observation supported by the field and faunal studies of Ludvigsen (1975) and Chatterton and Ludvigsen (1976).

P. flexuosus symmetricus is common in collections from the lower part of the Esbataottine Formation, deposited in deeper water shelf environments. The accompanying fauna includes Belodella erecta (Rhodes and Dineley) and Appalachignathus delicatulus Bergström et al. Both of the latter taxa are present in the upper part of the type Chazy (Raring, 1972), in the type Black River Group (Votaw, 1971), and in the Copenhagen Formation, Antelope Valley, central Nevada (Ethington and Schumacher, 1969).

### Fauna 7

The index species of Fauna 7, *Phragmodus inflexus* Stauffer, is rare in the sections studied (this species was only positively identified from P1665:507). Votaw's unpublished study (1971) of the conodonts of the type Black River Group lists several taxa common in Fauna 7. Many of these are also present in the southern Mackenzie Mountains. These include *Appalachignathus delicatulus* Bergström *et al.*, *Belodina compressa* (Branson and Mehl), *Oistodus nevadensis* Ethington and Schumacher s.f., *Plectodina aculeata* (Stauffer) and *Triangulodus* n. sp. B.

*Polyplacognathus ramosus* Stauffer is present in one of the collections assigned to this faunal unit, and a specimen of *Scyphiodus* is present in another. Collections assigned to Fauna 7 and the Blackriveran have been obtained from sections A, B, G, H and P.

Relatively few fibrous elements are present in collections of this age (with the exception of section B). This contrasts with the large number of fibrous elements in the Blackriveran strata of eastern North America and the central Midcontinent region. This difference is probably ecological due to the shallow water aspect of the eastern Midcontinent strata.

All of the collections assigned to Fauna 7 are from the middle and upper parts of the Esbataottine Formation or the upper part of the Sunblood Formation (where the Esbataottine Formation is missing).

### Fauna 8

Fauna 8 is characterized by the co-occurrence of *Phragmodus undatus* Branson and Mehl and *Plectodina aculeata* (Stauffer). The latter species, *P. aculeata*, is not known from rocks younger than lower

Kirkfieldian, while *P. undatus* first occurs in the Rocklandian and ranges up into much younger strata. Fauna 8 probably represents the Rocklandian and the lower part of the Kirkfieldian (Sweet *et al.*, 1971).

This fauna is best represented in collections from section E (E2450:747 to E2690:820). *Phragmodus undatus* Branson and Mehl is the dominant species, with more than one thousand elements in collections E2450:747 and E2625:800. Other taxa present in these horizons include: *Plectodina aculeata* (Stauffer), *Panderodus gracilis* (Branson and Mehl), *Belodina compressa* (Branson and Mehl), *Amorphognathus* sp. A ? *Bryantodina* ? *abrupta* (Branson and Mehl).

Conodont collections from the uppermost part of the Esbataottine Formation and the lowest part of the Whittaker Formation can generally be assigned to Fauna 8 (with the exception of some collections from near the base of the Whittaker Formation that are assigned to Fauna 9). Elements of this fauna have previously been reported from the upper Bay Fiord Formation, Arctic Canada (Barnes, 1974); the Thumb Mountain Formation of Arctic Canada (Barnes *et al.*, 1976); and the Hull Formation of Ontario (Uyeno, 1974).

### Fauna 9

Ordovician faunas younger than Fauna 8 (Faunas 9-12) are difficult to identify if their characteristic taxa, mainly species of *Amorphognathus*, are absent. This genus is rare in the southern Mackenzie Mountains (a few specimens of *Amorphognathus* were obtained from the fine clastic facies). Some species of *Belodina* and *Panderodus*, characteristic of the younger faunas, are also absent from present collections. Both *Plectodina furcata* (Hinde) and *Aphelognathus* *kimmswickensis* Sweet *et al*. make their first appearance in Fauna 9 (Sweet *et al*., 1975), and since these taxa are common in the southern Mackenzie Mountains, they may be used to distinguish between Faunas 8 and 9. Fauna 9 ranges from the middle Kirkfieldian to the lower Shermanian (Sweet *et al*., 1971).

This fauna is identified in a number of the sections in the southern Mackenzie Mountains (sections D, M, E, A, B, C, J, I, H and R). The most diverse collections of this age were obtained from section E (E2700:823; E2740:835; E2760:841; E2780:847). In this section, numerous specimens of *Plectodina furcata* (Hinde), *Aphelognathus kimmswickensis* Sweet *et al*., and *Drepanoistodus suberectus* (Branson and Mehl) are present. Smaller numbers of specimens of other taxa also present include: *Staufferella falcata* (Stauffer), *Panderodus gracilis* (Branson and Mehl), *Phragmodus undatus* Branson and Mehl , and *Bryantodina* ? *abrupta* (Branson and Mehl). To the east of this section, from probably shallower waters, the faunas are less diverse in this interval, and mainly consist of *P*. *furcata*, *A*. *kimmswickensis* and simple cones (belonging to *Drepanodus* and *Panderodus*). Section H is an exception, since *Phragmodus undatus* is common in collections from that section. This fits the deep platform aspect of this part of the column at section H (argillaceous limestones and graptolitic shales), and its position in the centre of the Root Basin (see paleogeographic reconstructions of Ludvigsen, 1975, fig. 10).

Fauna 9 occurs above the base of the Whittaker Formation in most sections, but occurs close to the base of that formation in some sections where there may be a small disconformity between the base of the Whittaker Formation and the underlying units (sections D and M). In stadial terms, Fauna 9 represents the middle Kirkfieldian to the lower Shermanian.

### Fauna 10

There are problems in distinguishing Late Ordovician strata in the southern Mackenzie Mountains, with strata of this age being assigned to the Whittaker, Road River and Mount Kindle formations. All of these apparently, at least in some sections, range up into the Silurian. I believe that none of the collections described here from the Whittaker Formation are younger than early Late Ordovician (Fauna 10 to early Fauna 11), since all of the highest conodont bearing collections contain *Belodina compressa* (Branson and Mehl), a species that does not usually range above this level (Sweet *et al*., 1971, suggested that this species ranges as high as the lower part of Fauna 11). Unpublished data from Arctic suggests that the species may range as high as Fauna 12 (C. R. Barnes, oral communication).

Because no diagnostic taxon of this fauna was found in strata of the southern Mackenzie platform, I have attempted to recognize it on the basis of negative evidence. Samples that occur above those assigned to Fauna 9, and lack the diagnostic taxa of Fauna 9 (*P. furcata* and *A. kimmswickensis*), but contain *Belodina compressa* (Branson and Mehl), are tentatively assigned to Fauna 10. These usually consist of a restricted (low diversity) fauna in which only *Panderodus gracilis* (Branson and Mehl), *B. compressa* and *Drepanoistodus suberectus* (Branson and Mehl) are present. Their age could be younger than Fauna 10.

## C. Distribution of Conodonts from the Clastic Facies

### 1. Late Cambrian Faunas

All the Cambrian collections from the study area came from the westernmost section, section K (Text-fig. 1). Although conodonts of this age are rare, their presence here is of considerable paleobiogeographic and biostratigraphic significance. The stratigraphic distribution of these forms, in section K, is similar to those of other regions of western North America (southern Alberta, Derby *et al.*, 1972; Great Basin, Miller, 1975). The paleogeographic position of section K is near the eastern margin of the Selwyn Basin.

The following collections from the lower part of the Rabbitkettle Formation are almost certainly Cambrian in age: K235:72, K270:82, K390:119, K525:160 and K715:218. The stratigraphically higher samples, K880:268 and K995:303, are assignable to the *Missisquoia* Zone and are probably earliest Ordovician in age.

Phosphatic microfossils obtained from two samples collected from low in section K (K270:82 and K390:119) are similar to the problematic Early Cambrian taxa *Pelagiella lorenzi* Kobayashi and *Anaberella indecora* Missarzhevsky, illustrated by Matthews and Missarzhevsky (1975). A few unnamed conodont-like microfossils also occur in these collections, but the only identifiable 'conodonts' obtained from them are specimens from K390:119, namely: '*Furnishina*' ? sp. s.f., a long ranging Cambrian taxon (Müller, 1971). Thus, the exact age assignment of these two samples is uncertain.

a. *Proconodontus Zone*: Recently, Miller (1975) attempted to establish a sequence of conodont zones from the Upper Cambrian *Saukia* Zone to the Lower Ordovician *Symphysurina* Zone. The first appearance of the characteristic elements of his lower unit, the Proconodontus Zone, coincides with the base of the Saukia Zone (based on trilobites); and the disappearance of these elements coincides with the extinction of several trilobite and conodont taxa at the top of the Saukiella serotina Subzone of the Saukia Zone. In ascending order, Miller recognized four subzones of the Proconodontus Zone: Proconodontus n. sp., Proconodontus muelleri Miller s.f., Proconodontus notchpeakensis Miller s.f. and Oistodus minutus Miller s.f. His succeeding zone for the interval from the Corbinia apopsis Subzone of the Saukia Zone (uppermost Cambrian) to the lower part of the Symphysurina Zone (Lower Ordovician) is the Cordylodus proavus Zone. Miller recognized five subzones in the C. proavus Zone.

Miller (op. cit.) noted that elements of the Proconodontus Zone generally occur in carbonate rocks representative of shallow marine environments, whereas the characteristic elements of the Cordylodus proavus Zone may occur in sediments representative of both shallow and deep water environments (Landing, 1976a, has reported a Proconodontus Zone fauna in the deep water facies of the Appalachian Mountains).

Conodonts collected from a slightly higher sample, K525:160, represent the genera 'Furnishina', 'Hertzina', 'Prooneotodus' and Proconodontus. Although 'Furnishina', 'Hertzina' and 'Prooneotodus' are known to range from the Lower to the Upper Cambrian, the presence of Proconodontus suggests a post-Franconian age (Müller, 1971; Miller, 1975). The species present is closest to Proconodontus muelleri Miller s.f. One of the proconodontid elements in this collection is close to the specimens of Proconodontus ? primitivus (Müller) s.f. illustrated by Druce and Jones (1971). P. ? primitivus occurs first in the Upper

Cambrian at a level somewhat below the first occurrence of P. muelleri (Müller, 1971). A few primitive proconodontids also occur in this collection (Proconodontus ? sp. A of this study). Thus K525:160 belongs to the Proconodontus Zone, and can probably be assigned to the lower part of that zone (the P. n. sp. or P. muelleri Subzones of Miller, 1975).

A more diverse fauna was obtained from sample K715:218, 58 meters higher in the section [Proconodontus notchpeakensis Miller s.f., Proconodontus muelleri muelleri Miller s.f., Oneotodus nakamuri Nogami s.f., New Genus New Species 1, Oneotodus gracilis (Furnish) s.f., and an oistodiform element Oistodus cambricus Miller s.f.]. The oistodiform element is apparently intermediate between Oistodus cambricus Miller s.f. and Oistodus minutus Miller s.f. Miller (in Klapper et al., 1973) suggested that such a transitional oistodiform element might form part of the Proconodontus notchpeakensis Miller s.f. apparatus. K715:218 may be assigned to the Upper Cambrian Proconodontus notchpeakensis Subzone.

Collections from the Rabbitkettle Formation, taken above K715:218 (K880:268, K995:303 and K1155:352), have been provisionally included in the Ordovician.

### 2. Tremadocian Faunas

a. Fauna A: The lowest sample containing Cordylodus proavus Müller s.f. was obtained from K880:268. The same horizon provides the lowest occurrence of Missisquoia. Derby et al. (1972) provisionally assigned the C. proavus and Missisquoia Zones to the Ordovician. Proconodontid elements are present in this collection, but appear to be slightly asymmetrical (*Proconodontus* cf. *P. muelleri*). *Oneotodus nakamuri* Nogami s.f. is present in small numbers. Some cordylodids present are similar to the forms illustrated by Druce and Jones (1971) as *C.* cf. *C. proavus* s.f., although most of them can be included in *Cordylodus proavus* s.f. Sample K880:268 clearly belongs to the *C. proavus* Zone of early Tremadocian age.

b. *Fauna B*: Sample K995:303, 35 meters higher, contained several oneotodid elements that are tentatively assigned to the form species *Oneotodus nakamuri* Nogami s.f., *Oneotodus gracilis* (Furnish) s.f., *Oneotodus* n. sp. A and *Proconodontus* cf. *P. muelleri*. All the samples collected from above K995:303 are of definite Ordovician age. Some unidentifiable primitive platform elements were obtained from a sample 49 meters above K995:303 (K1155:352).

3. Basal to Middle Arenigian Faunas

a. *Basal Arenigian Conodonts*: About 227 meters higher in the section (K1900:579), a sample contained a number of identifiable elements, including: *Oneotodus variabilis* Lindström s.f., *Protopanderodus rectus* Lindström s.f., *Acodus* n. sp. A and *Drepanoistodus forceps* (Branson and Mehl). Although these taxa are long ranging, they are most abundant in strata of basal Arenigian age (both in the Baltic region and in North America). *Oistodus linguatus* Lindström s.f., included here in *Acodus* n. sp. A, has been listed with elements of Fauna D in the Fillmore Limestone, Great Basin (Ethington and Clark, 1971), and was also recovered in Lindström (1955) from strata of Arenigian age in Sweden. It is not known to occur in older rocks.

b. *Early Arenigian (Oepikodus evae Zone) conodonts*: The next four samples, collected in sequence higher in this section, K2020:616, K2050:625, K2090:637 and K2145:654, all yielded conodont collections assignable to the Oepikodus evae Zone. In the light of Van Wamel's work (1974) on the Lower Ordovician conodont faunas from Öland in Sweden, it is possible to assign the two highest of these collections (K2090:637 and K2145:659) to the Prioniodus crassulus Assemblage Zone of the O. evae Zone on the basis of the occurrence of P. crassulus (Lindström) without Prioniodus navis Lindström. The lower collections (K2020:616 to K2050:624) contain the following significant conodont taxa: Gothodus microdentatus Van Wamel s.f., Oepikodus evae (Lindström), Oistodus lanceolatus Pander, together with Prioniodus crassulus (Lindström) and Periodon flabellum (Lindström).

Ethington (1972) reported the occurrence of Oepikodus evae in the Ninemile Formation of central Nevada. Ethington's Ninemile Formation faunal lists also include many of the forms that occur in this part of section K. Uyeno (in Dean, 1973) provided a list of conodonts from unit 2 of the Ordovician section at Keele Range, Yukon Territory, that includes O. evae. Thus, the occurrence of a characteristically North Atlantic fauna of Latorpian and possibly early Volkhovian age on the western side of North America is now well established.

### 4. Late Arenigian ? or Early Llanvirnian Faunas (Eoplacognathus planus Zone)

Middle Ordovician conodonts occur in the Road River Formation of section K (K2300:701), above beds containing Lower Ordovician conodonts (K995:303 to K2200:671). Collection K2300:701 contains a single specimen of Drepanodus arcuatus (Lindström). This appears to be the arcuatiform element, Acontiodus arcuatus Lindström (few striations, a high cusp-to-base ratio and a streamlined shape), and also occurs in the next collection, K2375:724. Collection K2375:724 contains many characteristically North Atlantic type Middle Ordovician taxa such as Amorphognathus, Eoplacognathus, Periodon, and Protopanderodus. In several aspects, this fauna is similar to that of the Lévis Formation, Zone D1 (Uyeno and Barnes, 1970). It also has some affinities with the faunas of the Fort Peña Formation, Marathon Basin, Texas (Bradshaw, 1969), the middle unit of the Table Head Formation, Newfoundland (Fåhraeus, 1970), the Pratt Ferry Formation, Alabama (Sweet and Bergström, 1962), and the Mystic Formation, Quebec (Barnes and Poplawski, 1973).

Recently Dzik (1976) has illustrated several elements from the latest Arenigian to Caradocian sequence of northern Poland. The fauna depicted for the lower Llanvirnian interval is very similar to that present here. Important constituents include Periodon aculeatus Hadding (early form); Eoplacognathus planus (Sergeeva); Protopanderodus cooperi (Sweet and Bergström), Oistodus venustus Stauffer s.f., Cordylodus ramosus Hadding , Drepanoistodus basiovalis (Sergeeva), Multioistodus subdentatus Cullison. Most of the taxa and over ninety percent of the elements in this collection are North Atlantic in aspect.

Stratigraphically, the occurrence of the Eoplacognathus planus fauna appears to be older than the well-known earliest Middle Ordovician fauna of the Eoplacognathus suecicus Zone (Bergström, 1971). Two of the taxa illustrated by Dzik (1976), Periodon aculeatus zgierzensis Dzik and Eoplacognathus zgierzensis Dzik, are identical to Periodon *aculeatus* Hadding (early form) and *Eoplacognathus planus* (Sergeeva). This, therefore, suggests an early Llanvirnian age for K2375:724.

The fauna from this horizon (K2375:724) may also be dated as late Arenigian for both *Multioistodus subdentatus* and *Leptochirognathus* n. sp. A are also present here. As noted earlier both of these occur in the adjacent Sunblood Formation in horizons that are Whiterockian in age (Fauna 3) (Bergström, 1977, considered Fauna 3 to be late Arenigian in age). Thus this horizon is of late Arenigian or early Llanvirnian age.

### 5. Late Llanvirnian?/Llandeilian Faunas (*Pygodus serrus* Zone)

A collection made available (Locality 5) by D. G. Perry contains a distinctive North Atlantic fauna belonging to the *Pygodus serrus* Zone. Both the pygodiform and the haddingodiform elements of *Pygodus serrus* Bergström are present.

The presence of this zone in western North America is of considerable biostratigraphic significance for, in conjunction with the reported occurrence of *Pygodus anserinus* Lamont and Lindström in the lower part of the Copenhagen Formation of Nevada (Bergström, 1971, p. 124), it now seems possible to use Bergström's North Atlantic lower Middle Ordovician zonation scheme for the deeper water facies of western North America. This occurrence supports the earlier contention that the North Atlantic Province can be extended to include the western Mackenzie Mountains (Tipnis *et al.*, 1975).

Besides *Pygodus serrus*, the collection from Locality 5 includes: *Polyplacognathus friendsvillensis* Bergström, *Periodon aculeatus*, Drepanoistodus forceps (Lindström), Drepanodus arcuatus (Pander), Walliserodus ethingtoni (Fåhraeus), Panderodus gracilis (Branson and Mehl), Belodella sp. aff. B. n. sp. Barnes and Poplawski, Strachanognathus parvus Rhodes, and elements that appear somewhat similar to the form genera Cyrtoniodus and Phragmodus (Phragmodus n. sp. B of this study). The ambalodiform element of P. friendsvillensis suggests (see Bergström, 1973a) that this collection may belong to the lower part of the P. serrus Zone. The specimens of Phragmodus are close to homologous elements of Phragmodus flexuosus Moskalenko, suggesting a possible correlation of the P. serrus Zone with the Midcontinent Chazyan Faunas 5 and 6.

### 6. Caradocian Faunas (Amorphognathus superbus Zone)

A single collection from Locality 2 has yielded a few incomplete but identifiable elements of Amorphognathus superbus (Rhodes) and Periodon grandis (Ethington). Both these species are characteristic of early Late Ordovician Faunas 10 and 11, and suggest a late Caradocian age (Sweet et al., 1971).

# CHAPTER IV

# STRATIGRAPHIC DISTRIBUTION AND SIGNIFICANCE OF CONODONTS

## A. Stratigraphic Distribution and Significance of Conodonts from the Southern Mackenzie Platform

The extended range of the material at hand permits one to observe and study important conodonts from Late Cambrian to late Middle Ordovician time. Wherever possible, attention is directed to conclusions from previous studies that are believed to be pertinent to the present work. In some instances the nature of the material at hand justifies specific discussion and/or evaluation of the taxa.

The Late Cambrian conodont collections contain the important genus *Proconodontus* . Distribution of this genus has been previously discussed by Miller (1969), Müller (1973) and Miller (1975); and its occurrence in the Rabbitkettle Formation appears to be quite consistent with these studies. An upper limit of early Tremadocian for this genus is supported.

Two important genera, namely *Oneotodus* and *Cordylodus*, are present in the Tremadocian collections from the Rabbitkettle Formation (for a discussion on the phylogeny of these genera see Druce and Jones, 1971, fig. 15). The two important species, *Cordylodus proavus* Müller and *Oneotodus nakamuri* Nogami, occur at the same stratigraphic level in Australia, Iran and the Great Basin of western North America.

The sudden diversification of conodonts in late Tremodocian/ Arenigian time is well documented in collections from the upper Broken Skull Formation and to a lesser extent the lower portions of the Road River Formation. Conodonts from the Broken Skull Formation are numerous and diverse and are characterized by the following multielemental genera: *Drepanoistodus*, *Paroistodus*, *Triangulodus* and *Juanognathus*, together with *Scolopodus*, *Protopanderodus*? and *Oistodus*.

The important Midcontinent taxa, from the lower part of the Broken Skull Formation, include scolopodids (*Scolopodus rex* Lindström *sensu* Serpagli and *S*. *quadraplicatus* Branson and Mehl), *Protopanderodus*? sp. aff. *P*. ? *tricarinatus* Barnes and Poplawski, and *Juanognathus jaanussoni* Serpagli.

The predominantly North Atlantic type taxa present low in the Broken Skull Formation are *Paroistodus amoenus* (Lindström) *sensu* Van Wamel, *Drepanodus arcuatus* Pander *sensu* Lindström, *Drepanoistodus forceps* (Lindström), *Coelocerodontus* n. sp. A and a few primitive pygodiform elements. These taxa show some similarity with conodonts present in the lower part of the *Paroistodus parallelus* Zone of Lindström (Lindström, 1971). The early occurrence of *Pygodus* is of considerable significance. In fact, it now appears that *Pygodus* is widely distributed in North America and may be more common to it than previously thought (see Barnes and Fåhraeus, 1975).

Higher up, within the Broken Skull Formation, the important species *Acodus deltatus deltatus* Lindstrom, *Walliserodus* sp. aff. *W*. *australis* Serpagli and *Triangulodus* n. sp. A occur. The significance of *A*. *deltatus deltatus* to the phylogeny of Ordovician conodonts has been stressed previously by MacTavish (1973) and Sweet and Bergström (1972).

These are joined higher up by a new fauna whose components include Paroistodus parallelus (Pander), Oistodus lanceolatus Pander, Stolodus sp. aff. S. stola (Lindström), Acodus deltatus deltatus Lindström, and New Genus New Species B and C (whose basal sheath, structural plan and colours are similar to those of Stolodus sp. aff. S. stola).

As was the case with the Arenigian fauna described by Serpagli (1974), several species that normally do not occur with the Paroistodus fauna elsewhere are dispersed throughout the Broken Skull Formation, especially near the top. These include Acodus sweeti (Serpagli). Reuterodus andinus Serpagli, Oistodus pseudoramis Serpagli s.f., and Juanognathus variabilis. In the Broken Skull Formation, however, Juanognathus variabilis occurs at a higher stratigraphic level, where it is joined by Oepikodus communis (Ethington and Clark), Drepanoistodus basiovalis (Sergeeva) and Triangulodus robustus (Serpagli).

The highest collections from the Broken Skull Formation contain the taxon, Clavohamulus n. sp. 1, which extends the range of this genus well into the Lower Ordovician.

The important multielemental taxon, New Genus A of Sweet et al., 1971, is of considerable interest as its two elements (the oistodiform and ramiform) undoubtedly demonstrate a multielemental association, as witnessed by their co-occurrences in widely separated regions (southern Alberta, Ethington and Clark, 1965; El Paso Formation, Texas, Repetski, 1974; Great Basin, Nevada, Sweet et al., 1971; and Canadian Arctic, Barnes, 1974). This is in contrast to several older species whose multielemental reconstructions have not proven universally applicable.

The bulk of the Whiterockian collections, dominated by hyaline conodonts, includes the important multielemental genus Multioistodus.

Although initially described by Cullison (1938), the significance of Multioistodus was first emphasized with the study of conodonts from the West Spring Creek and Joins formations by Harris (1962), Harris and Harris (1964) and Mound (1965, 1965a). Later, Bradshaw (1969), perhaps taking a cue from the observations of Lindström (1964) in his discussion of the Roundya-Cordylodus transition series, recognized that the genus clearly required a multielemental status and described it in these terms, expanding its concept by including in it the genus Neomultioistodus Harris. The present study generally supports this conclusion. Moreover, the study has also revealed two multielemental taxa, New Genus New Species D and Leptochirognathus n. sp. A, which have affinities with Multioistodus. Both show a symmetry-transition similar to the Roundya-Cordylodus series of Lindström.

The late Whiterockian fauna is generally dominated by conodonts referred to as the Hyaline Prioniodid Series. This is an interesting assemblage of robust conodonts that shows affinities with both the older multioistodids and with the younger Middle Ordovician taxa. This intermediate position is well justified if one ignores the fact that the younger taxa are primarily lamellar conodonts. I have attempted to separate these elements into two species based upon the philosophy that one group is homologous with Multioistodus ("Eoneoprioniodus" n. sp. A) whereas the other has closer ties to the younger Phragmodus-Plectodina-Oulodus complex ("Phragmodus" n. sp. A). The absence of these hyaline prioniodids from younger Chazyan strata and their usual occurrence above Multioistodus subdentatus and related taxa indicate their importance stratigraphically and in terms of conodontophorid evolution.

The almost complete extinction of Multioistodus and the Hyaline Prioniodid Series was accompanied by the appearance of elements that form the stable members of the Middle Ordovician fauna. The three most important multielemental genera are Phragmodus, Plectodina and Oulodus. Others of lesser importance included here are Belodina, Panderodus, Triangulodus, and Appalachignathus.

Collections from the study area have yielded relatively few elements belonging to the hyaline genera such as Chirognathus, Leptochirognathus, Erismodus and Curtognathus, and as pointed out by Tipnis et al. (in press) the reason for this may be ecological.

Belodina and Panderodus are noted here because in the study area their first appearance in the stratigraphic column is considerably earlier than shown previously (early Chazy instead of Blackriveran). The obvious explanation for this must be the proximity of the Mackenzie platform to the transgressing sea waters of the Tippecanoe transgression. The Chazyan elements of both Panderodus and Belodina tend to be represented by forms that have a simpler (primitive or ancestral) appearance in comparison to the better known and well documented taxa from other regions.

Another interesting aspect noted in the distribution of Belodina is the apparent paucity of eobelodiniform elements that usually accompany the belodiniform elements (Bergström and Sweet, 1966).

It is also of interest to note that, based on gross morphologic features, an evolutionary link between "Phragmodus" n. sp. A (late Whiterockian) and Phragmodus flexuosus Moskalenko can be postulated (presence of several homologous elements made up of identical form genera). However, the former species is more hyaline in appearance while the latter is a true lamellar conodont (cancellate of Barnes *et al.*, 1973b). This clearly suggests that *white matter* may not be very significant in the taxonomy of conodonts (the lack of or paucity of white matter distinguishes the hyaline or 'fibrous' type from the lamellar or cancellate conodonts). Barnes *et al.* (1973a,b) have previously noted (and to some extent shown) that the absence of white matter within some Ordovician conodonts is generally restricted to conodont taxa dominant in extremely shallow water environments (possibly including abnormal salinities). If this is indeed true, it would not be surprising to find the homologous equivalents of many of the lamellar Middle Ordovician conodonts (e.g. *Phragmodus*, *Plectodina*, *Oulodus*) in the late Whiterockian plexus of the "Hyaline Prioniodid Series". In fact, Sweet and Schönlaub (1975) have recently suggested that the origin of a lamellar group, namely *Oulodus*, from a hyaline stock, probably *Erismodus* or *Chirognathus*.

The phylogeny of *Phragmodus* has been documented in Bergström and Sweet (1966), Sweet *et al.* (1971), Sweet and Bergström (1972), and Moskalenko (1972, 1973). The most obvious morphological change that affects species of *Phragmodus* through time is the gradual reduction of the sinuosity associated with the phragmodiform element, accompanied by a reduction in denticle size. This feature was noted by Tipnis *et al.* (in press). A contemporary study on the trilobite faunas from the same horizons (Chatterton and Ludvigsen, 1976) leads me to believe that this *Phragmodus* subspecies represents a relatively deeper or quieter water form whose apparent absence from the interior of the Midcontinent and possible presence in the Copenhagen Formation of Nevada may be ecological (see discussion for *P. flexuosus symmetricus* in Systematics). It should be noted that the Copenhagen Formation has yielded several elements characteristic of the North Atlantic Province (Ethington and Schumacher, 1969); and North Atlantic taxa are generally associated with deeper waters.

The phylogeny of Plectodina has been previously discussed by Bergström and Sweet (1966), Sweet and Bergström (1972), Sweet et al. (1975). For reasons clearly documented by Bergström and Sweet (1966), the earliest species of Plectodina, P. aculeata, was grouped into a multielemental apparatus consisting of six different elements. At one time this species was believed to be restricted to Faunas 7 and 8, but the occurrence of some of its elements in Chazyan rocks has since been noted by Raring (1972) and Tipnis et al. (in press). Recently, the phylogeny of P. furcata has been discussed in more detail by Sweet et al. (1975) wherein they introduced a different system of labelling the component elements from that proposed by Klapper and Phillip (1971) for their Type I apparatus.

Attempts to pigeonhole the two Plectodina species stratigraphically have led to some problems, as the distinction between homologous elements of P. aculeata and P. furcata is not always clear.

Evidence from the study area is not sufficient to warrant conclusions on the origin of this genus. Some of the minute conodonts that have been included with Oulodus n. sp. A (discussed below) are similar to early components of this species (it must be stated that an undoubted distinction between elements of Plectodina and Oulodus at this level is not possible as is evident from the discussions of the phylogeny of these two genera by Sweet and Bergström, 1972; Sweet and Schönlaub, 1975).

*Oulodus*, the last member of the *Phragmodus*-*Plectodina*-*Oulodus* trinity, also appears to be the most complex. Sweet and Bergström (1974) regarded this genus as the only real Midcontinent indigenous form, as its distribution is truly restricted to the Midcontinent. Like the other two genera, its phylogeny was discussed previously by Bergström and Sweet (1966) and Sweet and Bergström (1972). In the latter work, they regarded *Oulodus* as being closely linked to *Plectodina* and, together with it, forming the ancestral stock of most of the major conodont lineages of the Late Ordovician and later times. More recently, Sweet and Schönlaub (1975) have suggested that *Oulodus* may have been derived from a hyaline ancestor such as *Microcoelodus* (*Erismodus* of this study). The primitive oulodid species from the study area *Oulodus* n. sp. A occurs low in the Chazyan Fauna 5. Many of its components have chirognathid outlines (see Plate 21, figs. 1, 2, 3, 5) that appear to support the view of Sweet and Schönlaub, in the sense that *Oulodus* may have evolved from a hyaline ancestor.

*Triangulodus* n. sp. B is a multielemental species that appears to be restricted to the late Chazyan-early Blackriveran interval. Phylogenetically, this form may be related to *Triangulodus* *brevibasis* (Sergeeva) (the latter, however, has not been recovered from the study area). A few collections from upper Chazyan and lower Blackriveran strata have yielded elements of *Appalachignathus* *delicatulus*. The phylogeny of *Appalachignathus* has already been dealt with in considerable detail by Bergström *et* *al*. (1974). Evidence from the study area shows that spathognathodiform and possibly ozarkodiniform elements appear earlier (stratigraphically speaking) than the zygognathiform, trichonodelliform and eoligonodiniform elements.

## B. Stratigraphic Distribution and Significance of Conodonts in the Road River Formation

A sequence of conodont faunas recovered from the Road River Formation in many ways mimics the distribution of conodonts in the Baltic region. Some important Baltic genera are rare to absent in the present collections from the study area, including: *Paroistodus*, *Paltodus* and possibly *Baltiniodus* (the validity of this latter genus is in some doubt, see Sweet and Bergström, 1972). Of these, *Paroistodus* is, however, abundant in Arenigian conodont collections from the Broken Skull Formation (see discussion of Broken Skull conodonts).

The oldest conodonts obtained from the Road River Formation include: *Oneotodus variabilis* Lindström, *Protopanderodus rectus* (Lindström), *Drepanoistodus forceps* (Lindström), and *Acodus* n. sp. A. Elements of *Oepikodus evae* (Lindström), *Oistodus lanceolatus* Pander and *Prioniodus elegans* ? Pander join the latter taxa in younger collections, while *Prioniodus crassulus* (Lindström) occurs in still higher collections.

This entire sequence, except for the absence of paroistodids and paltodids, referred to above, is similar to that of the faunas occurring in the stages BIβ to BIIα of the Baltic region (Lindström, 1971).

The next collection, yielding younger taxa, belongs to BIIIα (Lindström, 1971) and includes conodonts that generally occur within the zone of *Eoplacognathus variabilis* (Sergeeva). Several important Middle Ordovician genera are well represented, namely: *Amorphognathus*, *Eoplacognathus*, *Periodon* and *Protopanderodus*. A single pygodiform specimen, *Pygodus* n. sp. 1 Uyeno and Barnes, bearing two rows of nodes and therefore a possible forerunner to *Pygodus serrus* (Hadding), also occurs in this collection. Although many of the platform elements here are broken, the overall affinity with the conodont fauna of the Baltic is clear. For possible significance of this collection, see discussion of Eoplacognathus, Periodon and Pygodus in section on Systematics.

The next younger collection includes Pygodus serrus (Hadding), the nominate taxa of the Pygodus serrus Zone of Bergström. The other conodonts here include Periodon aculeatus Hadding and Polyplacognathus friendsvillensis Bergström. The latter species has considerable biostratigraphic significance (Bergström and Carnes, 1976). The ambalodiform element of P. friendsvillensis is clearly closer to that of the early form of the species (see Bergström, 1973a, fig. 2) and may even be ancestral to it. Two additional taxa present in this collection deserve mention: Strachanognathus parvus Rhodes, a rather peculiar looking conodont, which has only been recovered elsewhere in North America from Newfoundland (Bergström et al., 1974); and Phragmodus n. sp. B, which includes phragmodiform and cyrtoniodiform elements somewhat reminiscent of the early Chazyan species Phragmodus flexuosus Moskalenko.

Several collections, from presumably younger strata, provide little useful information. These conodont faunas are generally dominated by drepanodids and panderodids. One collection, however, has yielded amorphognathids and periodontids that belong to the late Caradoc species Amorphognathus superbus (Rhodes) and Periodon grandis (Ethington), respectively. The evolution of Amorphognathus species has already been discussed by Bergström (1971). Both ambalodiform and amorphognathiform elements are present.

It should be stated that the distribution of the North Atlantic type conodonts in the Road River Formation, even with the limited material at hand, clearly points to the potentiality of this region in documenting evolutionary changes of Ordovician conodonts. It is clear that the hypothesized conodont lineages of Lindström (1971) and Bergström (1971) (based on European faunas) can be tested with material from the Road River Formation.

# CHAPTER V

# CONODONT PALEOECOLOGY AND BIOGEOGRAPHY

## A. Introduction

The status of conodont biogeography (provincialism) and its interdependence with or independence from conodont paleoecology is largely unresolved. During the 1960's the concept of two Ordovician faunal provinces became firmly entrenched (Bergström, 1973). One of these, the North Atlantic Province, occupied much of northern Europe and some parts of northeastern America (especially eastern Newfoundland). The other, the Midcontinent Province, included most of the North American craton (excepting the outer margins) as well as other areas such as Australia and Siberia. Some of the western European localities showed faunal 'mixing' (Bergström, 1973) [particularly Scotland, Wales and Ireland]. A similar distribution for many other groups was also noted (Berry, 1972). Most of the areas showing 'faunal mixing', when plotted on a world map, appeared to circle the Northern Atlantic Ocean. Wilson (1966) suggested that 'mixed' faunas perhaps represent portions of the ancient suture zone that once joined North America and north Europe, and which eventually 'split up' during the opening of the present Atlantic ocean. In 1970, Bird and Dewey presented a sophisticated model of the history of the Atlantic Ocean which included a Proto-Atlantic stage during the Paleozoic. According to their model, the Proto-Atlantic Ocean was gradually undergoing an expansion phase during the Cambrian and part of the Early Ordovician. At the end of the Early Ordovician, the closing (contraction) stage was initiated, eventually leading to the evolution of the Appalachian Mountains. Paleontologists were quick to point out that the noted Cambrian and Early Ordovician provincialism shown by many fossil groups concurred with this explanation (Berry, 1972; Valentine and Moores, 1972). The gradual breakdown of provincialism in post-Early Ordovician rocks was not that obvious and therefore more difficult to explain, but nevertheless seemed possible, especially by invoking dispersal of faunas along possible chains of volcanic islands (Neuman, 1972) that lay off the coast of northeastern America.

The discovery of almost identical 'anomalous' faunas even in western and southern parts of the American craton and the possible influence of ecology in the distribution of faunal provinces (Palmer, 1973; Cook and Taylor, 1975) led to a questioning of an explanation (of provincialism) based only upon the opening and closing of the Proto-Atlantic. Ironically, conodont workers during this period were generally quite restrained in their attempts to tie the distribution of conodonts with the history of the Proto-Atlantic (with the possible exception of Burrett, 1973). The most significant factor controlling the distribution of conodonts was believed to be temperature (Bergström, 1973), and to a lesser extent ocean currents (Lindström, 1969), especially as conodonts were thought to be pelagic.

The recognition of the two provinces was largely based on the presence of certain endemic taxa. It was also noted that within the Midcontinent Province, especially in North America, there existed a significant association of faunas with respect to lithologies, tectonic environments and geographic placement (Berry, 1972; Barnes et al., 1973a), with the outermost fauna showing affinities with the North Atlantic Province (Cook and Taylor, 1975; Tipnis et al., 1975, amongst others).

Central to the theme of Ordovician provincialism is the paleogeography of the Ordovician continents, which includes a northeasterly trending paleoequator passing through the northwestern part of the North American Plate, with a rather temperate or even Arctic position for the North European Plate (Noltimier and Bergström, 1977). These data, if true, provide a plausible explanation for the distribution of the two provincial faunas (the Midcontinent and the North Atlantic) as being latitudinally controlled and/or temperature dependent. This idea was put forward by several workers (Bergström, 1973, 1977; Tipnis et al., 1975; and Barnes et al., 1973a, amongst others) and appears to receive added support from the present data as well as those provided by Cook and Taylor (1975).

Unlike the evidence from the eastern Appalachians, where considerable faunal mixing occurs, the two provincial faunas in the study area are clearly separated into two tectonic regimes, basinal and platform. The basinal fauna was of the North Atlantic type, where colder conditions pertained at depth. Because of the nearness of the paleoequator to this region, the North Atlantic taxa were restricted to deeper water (cooler) conditions associated with the Selwyn Basin environments.

Barnes et al. (1973a) associated the North Atlantic fauna with eugeosynclinal environments (meaning, perhaps, deep water). Aspects of this study received some criticism on this point (see Sweet and

Bergström, 1974). In a later study, Barnes and Fåhraeus (1975) presented two models, one applicable for North Atlantic conodonts and the other for Midcontinent conodonts. Only the Midcontinent model is applicable to the southern Mackenzie region. Obviously, therefore, the applicability of the model must be related to the geographic position of the area involved. A region nearer the temperate latitudes will not show as strong a faunal differentiation (e.g. eastern Appalachians) as that from the tropics (southern Mackenzie - ? western Utah), and the tectonic setting is bound to be a factor in the latter case. The fact that little or no differentiation is evident in the conodont faunas of the high paleolatitude Baltic region (Jaanusson and Bergström, 1977) provides additional evidence that temperature may have been a particularly important environmental parameter in controlling the distribution of conodonts.

In addition to the rôle of temperature in controlling the distribution of conodonts within a geographic region, the ideas of Barnes and Fåhraeus (1975) and of Ross (1973) are important. Barnes and Fåhraeus (1975) introduced the role of salinity into their discussion of Midcontinent faunas, especially as the region was near the Ordovician equator. Increased salinities through restricted circulation over a stable continental plate may effectively lead to faunal variations dependent on this environmental factor. Ross (1973) also introduced a new parameter, namely the stability of the crust, emphasizing the fact that a stable continental plate, latitudinally restricted (presumably the North American Plate), generally contains faunas that are environmentally controlled. Both of these ideas may be invoked in combination to express the faunal variations noted in the Midcontinent faunas.

## B. Conodont Biogeography

Conodonts of the southern Mackenzie region can easily be identified in terms of the 'faunas' proposed by Lindström (1976). The significance of Lindström's 'faunas' is twofold. First, they are based upon the existing distributional knowledge of conodonts from across the world and therefore present a concise summary of the state of the art. Secondly, it allows one to instantaneously suspect something 'unusual' when components of one 'fauna', belonging to one province, have migrated (?) into another (note the attempt of Sweet and Bergström, 1974, to explain the occurrence of Midcontinent elements in the North Atlantic Province; and the attempt of Lindström, 1976, to tie the 'mixed' faunas to a position near the provincial boundary in the case of conodonts from the Canning Basin, Australia). In the southern Mackenzie region there are several instances where one can attempt to assess the significance of 'fauna' types. In almost every instance one can explain the occurrence of a 'fauna' as the result of the existence of a facies or particular environment, thus providing strong evidence that the distribution of conodonts was dependent on environmental factors.

A dual set of 'faunas' exists for the Tremadoc. The lower Tremadocian Cordylodus oklahomensis 'fauna' (which includes C. proavus) is well represented over much of the Midcontinent, Australia, Korea and the Arctic. Diagnostic elements of this fauna have not been recovered in the Baltic region, but are known from deep water sediments (Landing, 1976a) marginal to the North American craton. (This reinforces the view of Barnes and Fåhraeus, 1975, that C. proavus may have been a pelagic form).

*C. proavus* is well represented in the Rabbitkettle Formation where it occurs along with some broken forms which may belong to *C. oklahomensis*. The depositional environment for this part of the Rabbitkettle Formation is somewhat problematic because although sedimentologically (the lithology of thin bedded calcareous shales and siltstones) and tectonically (near the eastern limit of the Selwyn Basin) a deep water environment is suggested, the nature of the accompanying fauna (abundant trilobites belonging to the *Saukia* zone, Ludvigsen, personal communication, 1975) supports a shelf environment. Perhaps, because of the position of section K close to the basin edge, the depth of water may not have been too great for the trilobite community to establish itself.

In the late Tremadoc two new biogeographic 'faunas' became established. The ACL Fauna (*Acanthodus*-*Chosonodina*-*Loxodus*) dominated the Midcontinent Province, and is also found in Australia, Siberia and Iran. It shares a pair of elements with the coeval *Paroistodus* Fauna of the North Atlantic Province, namely *Cordylodus angulatus* and *C. rotundatus*.

Diagnostic elements of the ACL Fauna do not occur in samples from the Rabbitkettle Formation, despite the presence of a good *C. proavus* fauna immediately underlying them. The abrupt disappearance of *Cordylodus* from higher samples, if true, may be interpreted to mean the oncoming of deeper water environments. Barnes and Fåhraeus (1975) suggested that *C. angulatus* and *C. rotundatus* were essentially shallow water forms and that a deepening of environment was unsuitable for them. The observed faunal changes in much higher collections of Arenigian and younger age (conodonts of deep water aspect, general absence of megafaunas, excepting some inarticulate brachiopods) document a deepening of the depositional basin.

The faunal affinity of a higher collection of this age from the Rabbitkettle Formation is unclear. However, it is interesting to note that in the Midcontinent Fauna B (Ethington and Clark, 1971), several distacodontids make their appearance (*Acodus oneotensis* Furnish, *Scolopodus iowensis* Furnish, amongst others), none of which are present here.

Elements of the *Paroistodus* 'fauna' on the other hand have been identified from slightly younger strata (early Arenigian) in section D, where collections include the upper part of the Broken Skull Formation.

*Paroistodus parallelus*, the leading species, occurs in younger rocks along with *Oepikodus communis*. The latter species, however, has not been recovered from areas where *O. evae* is present. Serpagli (1974) noted a very similar species, *O. intermedius*, which occurs slightly above *O. evae*, and associated the absence of *O. communis* to its having migrated away from the North Atlantic Province to the Midcontinent. It is equally likely, however, that the occurrence of *O. communis* in section D and that of *O. evae* in section K may reflect the relationship of these two taxa to environments; namely *O. communis* - shallow water, *O. evae* - deep water. This once again reemphasizes the importance of both the geographic and tectonic settings to the presence of 'faunas'.

The complexity of understanding the latest Canadian and earliest Champlainian can be tied to the problem of the Whiterockian Stage. It is generally accepted that in North America, the Canadian/Champlainian boundary is an unconformity that separates the upper part of the Sauk from the lower part of the Tippecanoe Sequence (Sweet and Bergström, 1976). Cooper (1956) introduced the Whiterockian Stage in North

America, prior to which the Chazyan was the accepted base of the Middle Ordovician. Although, in most instances, the lower and upper boundary of the Whiterock does fall within the defined range, it has been shown that often the strata identified as Whiterockian represent ages which differ from place to place. Much of the Whiterock was included in the Arenigian by Bergström (1977, fig. 3), while Derby et al. (1977) included the base of the Whiterock in the Llanvirnian. The upper limit is no less problematic (Bergström, 1971).

Barnes et al. (1973) approached the Whiterockian problem in a different way. They pointed out that Whiterock strata usually occupied a marginal position (as noted by Ross and Ingham, 1970) and are distinguished by different conodont faunas which they tried to correlate with paleotectonic regimes (see their fig. 3). This may be, as pointed out by Sweet and Bergström (1974), an oversimplification. However, the idea merits attention. As was noted by Bergström (1971) and Ethington (1977), the two Whiterockian faunas, which are identical to the two provincial faunas, namely North Atlantic and Midcontinent, occur in two separate depositional environments. It may be inferred from Ethington (1977) that faunal differences are related to environmental parameters. The situation is analogous to the provincial faunas across the southern Mackenzie platform to basin transition, and explains the distribution of the two Whiterockian provincial 'faunas' (Lindström, 1976, text-fig. 9). In the study area, the Periodon 'fauna' occupies the deeper water slope/basinal regime, whereas the Multioistodus/Histiodella 'fauna' is present in the less deep, shelf environments of the Mackenzie platform.

The younger biogeographic 'faunas' of Lindström (1976) come within the framework of the Periodon and Phragmodus 'faunas'. Both are well represented in the study area, the former from spot samples collected from the Road River Formation (Selwyn Basin) and the latter from several sections across the southern Mackenzie platform. Their distribution is consistent with the explanation offered earlier.

## C. Conodont Paleoecology

Barnes et al. (1973a) presented a model tying the regional distribution of conodonts (communities) throughout the Ordovician to certain paleotectonic settings. Although some aspects of this work were criticized by Sweet and Bergström (1974), some later studies (e.g. Lindström, 1976a, Sweet and Schönlaub, 1975, amongst others) have supported in part the conclusions of this work. Moreover, this work served to focus attention on the possible paleoecologic significance of conodonts [though ecologic restriction of conodonts had been suspected for some time (for a review see Barnes and Fåhraeus, 1975)]. It was implicit (not explicit) in this model that the distribution of Ordovician conodonts suggests a correlation with benthonic Ordovician invertebrates and therefore that conodonts may be benthonic. It was primarily this idea that created a mild furor amongst conodont workers.

Barnes and Fåhraeus (1975) divided Barnes et al.'s (1973a) earlier model into two parts, one pertaining to the conodonts from the Midcontinent Province and the other showing the distribution of conodonts in the North Atlantic Province. Both models invoked the principle of lateral segregation of conodonts with respect to depth. The general conclusion was that most conodonts were benthonic or nektobenthonic.

As noted earlier, this model, at least as far as the Midcontinent faunas are concerned, contained no major surprises. The relative distributions of the bulk of taxa considered were either known before or established by Barnes et al. (1973a). Tipnis et al. (1975), working on the conodont faunas from the southern Mackenzie Mountains, came to a similar conclusion. For all practical purposes, the model may be accepted as a plausible documentation of the general distribution of Midcontinent conodonts in the Ordovician.

The Barnes-Fåhraeus model for the North Atlantic conodonts as yet appears to be incomplete. Examination of their table (1975, fig. 3) shows more than 10 question marks. As pointed out by Bergström and Carnes (1976, pp. 52, 53), the littoral facies in several instances does not contain neurodonts or hyaline prioniodids. Also, as noted by Lindström (1976a), the distributional pattern of Oepikodus evae does not conform to the Barnes-Fåhraeus model. Moreover, it is surprising that the lateral segregation of conodonts in the North Atlantic Province had not become obvious earlier because, according to Lindström (1976a), the facies changes are greater in this province. Recent studies of Jaanusson and Bergström (1977) reinforces this lack of conformity of conodont faunas with lithofacies of the Baltic region.

The North Atlantic taxa occur in the study area as a distinct biofacies confined to the deeper water sediments of the Road River Formation. This generally corresponds to the continental margin/eugeosynclinal community of Barnes et al. (1973a). However, if the distributions of many of the elements of the North Atlantic taxa are tested against the Barnes and Fåhraeus model, some problems are apparent.

Interpreted in the light of the Barnes and Fåhraeus model, the data from the conodont taxa of North Atlantic aspect from the southern Mackenzie Mountains (see below), tend to show a regression taking place during the Ordovician within the Selwyn Basin, whereas other independent data tend to suggest that a transgression was occurring in that area at that time (Ludvigsen, 1975).

The Road River Formation at section K contains Arenigian to early Llanvirnian conodonts. Beginning with the early Arenigian, of the taxa listed by Barnes and Fåhraeus (1975), only *Prioniodus*, *Periodon* and *Oepikodus* are present. The presence of *Oepikodus evae* in adequate numbers would suggest a deep water environmental setting for this part of the Road River Formation (samples K2020:616 to K2145:654). Higher up, in Arenigian to lower Llanvirnian strata (K2375:724), a diverse conodont fauna occurs which is dominated by *Periodon* and *Amorphognathus*, with smaller amounts of *Eoplacognathus*, *Cordylodus*, and neurodonts (*Multioistodus*). According to the model, this would imply a considerable amount of shallowing and hence a regression (however, note position of section K in Ludvigsen, 1975, fig. 10). Additional samples from adjacent areas also provide similar conflicting data. The late Llanvirnian? - early Llandeilian conodonts (Locality 5) have *Periodon* and *Belodella*, of the taxa listed by Barnes and Fåhreus, although the most dominant conodont genus is *Pygodus*. According to the Barnes-Fåhraeus model, this would imply an intermediate to deep water position (probably the latter as *Pygodus* is present). This would suggest a transgression of some sort during this time. With respect to the eastern edge of the Selwyn Basin, the positions of Locality 5 and section K are not significantly different. Another sample from this area contains abundant graptolites, probably *Climacograptus* sp. along with several elements of *Amorphognathus* and a few specimens of *Periodon*. According to the model, this would indicate a shallowing of the region during this period. Whether to accept a shallow water environment for a sample which contains

|  | BIOFACIES IV | BIOFACIES III | BIOFACIES II | BIOFACIES I B | BIOFACIES I A |
|---|---|---|---|---|---|
| ROCKLAND-KIRKFIELD | AMORPHOGNATHUS<br>PERIODON | PHRAGMODUS | PLECTODINA | BELODINA<br>PANDERODUS* |  |
| CHAZY-BLACKRIVER | PERIODON<br>PYGODUS | PHRAGMODUS | PLECTODINA<br>APPALACHIGNATHUS | CURTOGNATHUS<br>ERISMODUS | CHIROGNATHUS<br>LEPTOCHIROGNATHUS |
| WHITEROCK | AMORPHOGNATHUS<br>PYGODUS? PERIODON | ?HISTIODELLA | "EONEOPRIONIODUS"<br>MULTIOISTODUS |  |  |
| DEPTH | DEEP SUBTIDAL ? | DEEP-SHALLOW SUBTIDAL ? | SHALLOW SUBTIDAL ? | INTERTIDAL TO SHALLOW SUBTIDAL ? | INTERTIDAL TO SHALLOW SUBTIDAL ? |
| LITHOLOGY | CALC. SHALE | ARGILLACEOUS LIMESTONE | LIMESTONE | DOLOMITE AND LIMESTONE | ARENACEOUS DOLOMITE OR LIMESTONE |
| PROVINCIALITY | NORTH ATLANTIC | MIDCONTINENT | MIDCONTINENT | MIDCONTINENT 'INTERIOR' | MIDCONTINENT 'INTERIOR' |

* See text for explanation

TEXT-FIG. 7. Diagram showing the distribution of conodont 'biofacies' in the Middle Ordovician rocks of the southern Mackenzie platform and Selwyn Basin (based partly on Barnes et al., 1973 and Tipnis et al., 1975).

abundant graptolites is a separate question and not within the realm of the present discussion. While the above arguments do not disprove the Barnes and Fåhraeus model, particularly as it applies to eastern North America, they do not actively support it as being valid for the western Mackenzie region.

Following the reasoning noted above, a deep water conodont community, made up of North Atlantic conodonts in the Road River Formation of the southern Mackenzie region, is established (Biofacies IV of this study). As was noted earlier, the distribution of Midcontinent taxa in Barnes *et al.* (1973a) and Barnes and Fåhraeus (1975) is in accordance with the distribution of conodonts in the southern Mackenzie region (Tipnis *et al.*, 1975). This includes the *Phragmodus* (Biofacies III, deep subtidal) community, the *Plectodina* (Biofacies II, ? shallow subtidal) community, and the "Fibrous" community (shallow water, ? shallow subtidal-intertidal). The last community can be separated into a Biofacies 1B (fibrous conodonts such as *Erismodus* and *Curtognathus*) community, and a Biofacies 1A (*Leptochirognathus* and *Chirognathus*) community.[1]

Text-figure 7 is an attempt to portray the distribution of some taxa (generic level only) that form important components of the proposed biofacies, and their relative positions in time (stratigraphically) and space (depth of water ? and proximity to shore ?).

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[1] The distributions of fibrous genera do not always show a mutually exclusive relationship with *Phragmodus* and *Plectodina* (especially those listed with Biofacies 1B). However, in two samples that contain *Chirognathus* and *Leptochirognathus*, collected near the top of the Sunblood Formation from strata of extremely shallow water aspect (arenaceous limestone, sandy dolostone or siltstones), elements of *Phragmodus* are either entirely absent or rare while *Plectodina* is poorly represented. Barnes and Fåhraeus (1975) noted that *Panderodus* may have a pelagic life mode. In the study area, *Panderodus* does in fact occur through all four biofacies, though is relatively sparse in Biofacies III.

# ADDENDUM

Two papers that came out recently have little bearing on the contents discussed in these chapters. In the first of these Shaw & Fortey (1977), attention is directed to the environmental setting for the various formations from the southern Mackenzie Region based on a study of the trilobites. Since most of the conclusions are in agreement and based on the results of Ludvigsen (1975), and Chatterton and Ludvigsen (1976), little if any additional information is provided.

The second paper by Fortey and Barnes (1977) stresses the general conformity of the conodont and trilobite communities for the Arenigian/ early Llanvirnian of Spitsbergen. Although much of this study deals with slightly older conodonts, their discussions are not in conflict with data provided here (in some respects these provide independent corroboration of some ideas expressed by me). One point of significance is the distribution of simple cone taxa such as *Drepanodus* (*D. arcuatus*), *Drepanoistodus* (*D. forceps*), and *Paroistodus* (*P. parallelus*), which Barnes and Fåhraeus (1975) believe to be pelagic in habit. In the southern Mackenzie region, they are more common in the platform sediments, and are poorly represented in basinal strata of the Road River Formation. This does not necessarily mean that they were *not* pelagic. Numerically, the Early Ordovician conodonts from the Broken Skull Formation far exceed the conodonts from coeval strata of the Road River Formation, and viewed in terms of percentages, the difference is not very dramatic.

# CHAPTER VI

## SYSTEMATICS AND TAXONOMY

### A. Introduction

Conodonts represent skeletal components of some unknown marine organism whose zoological affinities are still unclear (despite some recent attempts to recognize the animal, Bischoff, 1973; Lindström, 1973, 1974; Melton and Scott, 1973; Morris, 1976). However, lack of knowledge about the animal has not impeded the study of this group, largely because of the great value of conodonts in biostratigraphy. One of the most damaging aspects of the use of conodonts purely as biostratigraphic indices was the tendency to ignore important biological associations of different conodont elements. The conodont apparatus was neglected and form taxa proliferated. The fact that a number of conodont elements of different forms belonged to a single animal was first suggested by Hinde (1879), and later demonstrated by Schmidt (1934), Scott (1934), Du Bois (1943) and Rhodes (1954). For practical reasons (the difficulty of recognizing the natural assemblages or apparatuses of the conodont animals), these works were largely ignored prior to the 1960's.

The decade of the 1960's was important to a realistic progress in conodont studies. A number of important works on the association of conodont elements into multielement apparatuses or taxa appeared during that time, including: Hass, 1962; Sweet and Bergström, 1962; Walliser, 1964; Lindström, 1964; and Bergström and Sweet, 1966, amongst others. One aspect, realized by the majority of these workers, was that the form taxonomy as used at the time was completely artificial, as each new taxon did not represent a new species of the conodont animal. The stage was being set for implementing a multielement taxonomy, wherein a multielement taxon consisted of more than one form genus (and form species), and was believed to represent the 'natural' components of the conodont animal (see Sweet and Bergström, 1962, for the first such attempt).

Many important papers appeared in the early 1970's (Lindström, 1970, 1971; Bergström, 1971; Klapper and Phillip, 1971; and those from the proceedings of the symposium on conodont taxonomy at Marburg - Lindström and Ziegler, 1972). The academic exchange at that symposium did much to firmly entrench the usage of multielement taxonomy. Part of the reason for doing so may have been the rejection of the Moore and Sylvester-Bradley proposal (1957) made to the International Commission on Zoological Nomenclature for formalizing 'parataxa' for fossil parts (and conodonts) that could not be identified in terms of the whole animal.

One possible approach stressed at the Marburg symposium was that the rules of priority, as stated in the International Code of Zoological Nomenclature, 1961, be followed in naming of multielement taxa, so that if a multielement species is recognized, the first described component of that species becomes its name bearer. However, if all of its elements were described simultaneously, then conventionally the component whose skeletal structures appear to change more rapidly (through geologic time) be selected as its name bearer (a suggestion of Sweet and

Bergström, 1970).

It was also agreed that a dual system of nomenclature should be adopted. Linnéan nomenclature should be applied both to single element taxa (s.f.), where they are not known to belong to multielement taxa, and to multielement taxa. The individual components of the latter, however, should not be identified by their Linnéan names but by using a different scheme (e.g., by attaching the suffix "form" at the end of the form-genus or by the number and letter system of labelling as used by Klapper and Phillip, 1971 or Sweet _et_ _al_., 1975). Such a procedure, although complex, is probably the most practical way of solving the dilemma of conodont taxonomy [see Chatterton, 1974 (p. 1466) for suggested treatment of form taxa].

## B. Conodont Classification

Several attempts in the past have been made to classify conodonts. Most of the early ones, of necessity, were based on gross morphological features (e.g., cone types, compound types, platform types). The first serious attempt at conodont classification began with Ulrich and Bassler (1926) who erected the Order Conodonta and established 5 families. The next was an addition of two suborders (by Branson and Mehl, 1944), namely Neurodontiformes, which included conodonts showing "fibrous" structure (hyaline or without white matter), and Conodontiformes with laminated structure (with white matter). These workers recognized 6 families. Hass (1962) was the first to use a separate biological classification for conodont assemblages.

Lindström (1964), in one of the most fundamental contributions to conodont taxonomy, showed that most conodonts followed a basic symmetry plan which could be recognized through many lineages of different ages (e.g. the *Cordylodus*-*Roundya* transition, the *Trichonodella*-*Oulodus* transition, the *Prioniodus* plan). Lindström published his views on suprageneric taxonomy in 1970. His conclusions were based on several important criteria such as the knowledge of 'natural assemblages', probable evolutionary sequences, gross morphology as well as micromorphology, stratigraphic occurrences and histology. Lindström divided the conodonts into two orders, Westergaardodinida and Conodontophorida. The former represented a somewhat problematic phosphatic group of microfossils which were either cone, U or W shaped, and contained organic substance with variable phosphatic encrustations and *no* white matter. Their range was fairly restricted: Middle Cambrian to Lower Ordovician. The genera included were '*Furnishina*', '*Hertzina*', '*Proacodus*' and '*Westergaardodina*'. This group could be included in the para- or protoconodonts of Bengston (1976).

The order Conodontophonida was divided into eight superfamilies, twenty families, with two of the families further subdivided into two additional subfamilies. This group coincides with the euconodonts of Bengston (1976).

In a later paper, Sweet and Bergström (1972) discussed the evolution and suprageneric classification of Ordovician conodonts and suggested some revisions. The most important was the separation of *Plectodina* and *Phragmodus* from the Periondontidae into a new family, the Cyrtoniodontidae. At that time, they believed that *Oulodus* should be included in the latter family. However, in a later study, Sweet and Schönlaub (1975) modified this earlier view and included *Oulodus* in the family Chirognathidae.

An important aspect of the paper by Sweet and Bergström (1972) was their recognition of the three basic patterns of Ordovician multielemental taxa. The first of these, the Type I or 'simple-cone' apparatus, contains two categories, monoelemental (having only one morphologic type of conodont element = s.f. in taxonomy), and multielemental (with more than one morphologically distinct component which may or may not show form-transition between the elements within the apparatus). The second apparatus type, the Type II or 'ramiform-apparatus', includes those taxa whose apparatuses consist of elements having one or more processes. The basic symmetry transitions in this type have been referred to earlier (symmetry transition in the sense of Lindström, 1964). Taxa belonging to this category form the bulk of the Middle Ordovician Midcontinent fauna. The third type, which consists of the Type III or 'ramiform-platform' apparatuses, is rare in the conodont faunas of the Midcontinent Province. It is much better represented in the North Atlantic Province, where the characteristic platform genera are Eoplacognathus, Amorphognathus, and Pygodus.

As far as the distribution of conodonts in the southern Mackenzie Mountains is concerned, the Type I apparatus is quite common in the late Canadian and early Middle Ordovician; the Type II apparatus is predominant in the Middle Ordovician; and the Type III apparatus appears at several levels from the early Middle to possibly the early Late Ordovician.

## C. Conodont Taxonomy

In this work, it is assumed that most, if not all, conodont elements originally belonged to multielemental apparatuses. Wherever possible, I have used multielement terminology for both previously described taxa and new taxa. In order to do so I have used published information of multielemental associations, recurrent associations within the samples, matching morphological features, symmetry transition series and any other facts available. It is realized that, at this time, it is not possible to prove (statistically) that any of these associations existed, but I feel that use of multielemental terminology simplifies Ordovician conodont biostratigraphy by reducing the number of names involved. Where it is not possible to place conodont elements in a multielemental association, on any reasonable basis, form terminology is used with s.f. added after the Linnéan name.

Multielemental nomenclature has been most successfully applied to Middle Ordovician conodonts of both Midcontinent and North Atlantic types. Possible anomalies in the reconstruction of Lower Ordovician conodonts (especially Arenigian) by Lindström (1971) were noted by Ethington (1972);[1] and recent studies of MacTavish (1973), Van Wamel (1974) and Serpagli (1974) have reaffirmed the problem rather than resolved it.

Most morphologic terms used here are in the sense of Klapper _et al_. (1973). Due to the large number of taxa in the conodont collections considered, it was not considered necessary to describe in detail every individual element. Nonetheless, I have tried to illustrate as many identifiable elements as possible.

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[1] Several reasons exist for possible incorrect reconstructions, and many of these have been discussed previously by Ethington (1972). However, one of the major reasons may be the similarity of niches occupied by several conodont species, which on decomposition yielded similar skeletal elements that are found in close proximity (i.e. in the same collections).

No attempt is made to name new taxa reported here (except for the *Phragmodus* subspecies, *P. flexuosus symmetricus*, named by Tipnis *et al.*, in press); and the treatment of previously described taxa is largely restricted to synonymy and remarks. Most reconstructed new multielemental taxa have been given letter names (e.g. New Genus New Species A or *Oulodus* n. sp. A), whereas suggested new form taxa are denoted by numbers (e.g., *Oistodus* n. sp. 1 or New Genus New Species 1). Some form taxa have only been identified at the generic level *Scandodus* sp.).

Dispersed throughout the collections are some problematic phosphatic microfossils. These are illustrated separately as, I believe, some of them may prove to be of biostratigraphic significance.

One philosophical question about multielemental taxonomy which troubles every Ordovician conodont worker is how much to believe about the reconstructed species. Working on the Middle and Upper Ordovician conodonts, one is quickly convinced that the majority of the multielemental reconstructions of Type II and Type III apparatuses are usable. The problem stems mainly from older conodonts, especially those of the Arenigian age, which are dominated by Type I apparatuses. This time period is characterized by conodonts that often defy placement into a small number of multielemental apparatuses. It appears that subtle differences exist between reconstructed apparatuses in different geographic regions (? allopatric speciation), e.g. Baltic fauna (Lindström, 1955; Van Wamel, 1974); South American fauna (Serpagli, 1974); Australian fauna (MacTavish, 1973); Great Basin fauna (Ethington and Clark, 1971, Ethington, 1972); El Paso fauna, Texas (Ethington and Clark, 1964); eastern Canada fauna (Barnes and Poplawski, 1973); Siberian fauna (Sergeeva, 1963, 1964); and southern Alberta fauna (Ethington and Clark, 1965). These faunas contain many similar elements, but lack some of the elements that apparently are associated with these elements (? in multielemental associations) in particular areas.

In this thesis, I have followed the multielemental taxonomy of Lindström (1971), Bergström (1971), Bergström and Sweet (1966), Barnes and Poplawski (1973), and Barnes (1977). To a lesser extent, especially for the Arenigian conodonts, I have benefited from the ideas expressed by Van Wamel (1974) and Serpagli (1974).

All illustrated material was photographed with the help of a Scanning Electron Microscope. Most of the illustrated types are to be placed in the Type Collection of the Geological Survey of Canada in Ottawa. These bear GSC numbers.

In most instances, the collections containing the various taxa described here are not listed separately. Their distribution can be seen in the Tables. Sample numbers of those not listed in the Tables are recorded in the text. Only the formations and/or the levels of occurrence within the formations are noted. Conodont names followed by s.f. indicate form-taxa, whereas those inside double quotation marks are assigned to the genus with doubt. The names inside the quotation marks are para- or protoconodonts.

## Genus Acanthodus Furnish, 1938 s.f.

Type species: Acanthodus uncinatus Furnish, 1938

### Acanthodus ? sp. s.f.

(Pl. 27, fig. 17)

Remarks: Two broken cusps having acanthodid-like posterior serrations are questionably included here.

Occurrence: One specimen occurs in the Cordylodus proavus Zone of the Rabbitkettle Formation. The other was recovered from the Esbataottine Formation (P1730:527).

Material: 2 specimens only

Illustrated Material: GSC50713

## Genus Acodus Pander, 1856

Type species: Acodus erectus Pander, 1856

Remarks: Klapper et al. (1973) noted that A. erectus, the type species of this genus, may be the prioniodiform element of a primitive adentate prioniodont that included the type species of Acontiodus Pander in its apparatus.

Two genera closely related to Acodus are Prioniodus and Gothodus. The possible relationship between Acodus and Prioniodus was discussed by MacTavish (1973) and Van Wamel (1974), while Serpagli (1974) noted the relationship between Acodus and Gothodus.

The revised diagnosis of Klapper et al. (1977) describes this genus as a multielement taxon with prioniodiform, ramiform and oistodiform elements. The prioniodiform elements consist of three divergent processes of which one is lateral.

### Acodus deltatus deltatus Lindström

(Pl. 10, figs. 5-10; Pl. 12, fig. 15)

Acodus deltatus altior sp. Lindström, 1955, p. 544, Pl. 3, figs. 27-29.

Distacodus rhombicus sp. Lindström, 1955, p. 556, Pl. 3, figs. 35, 36.

?Drepanodus latus Lindström, 1955, p. 564, Pl. 3, figs. 22, 23.

Oistodus linguatus Lindström, 1955, pp. 577, 578, Pl. 3, figs. 39-41.

Acodus deltatus deltatus Lindström. Klapper et al., 1977, pp. 7, 8, Pl. 2, figs. 8-13 (includes synonymy).

Remarks: Elements of A. deltatus deltatus were included under Prioniodus by Van Wamel (1974) [see also Landing, 1976]. Van Wamel's reconstruction incorporated trapezognathiform, roundyaform and prioniodiniform elements. These elements were omitted from the synonymy by Klapper et al. (1977). I have included both denticulate and undenticulate forms in this species. Ramiform elements of A. deltatus deltatus are likely to be confused with those of Walliserodus sp. aff. W. australis Serpagli. Elements of A. deltatus deltatus possess a thinner basal sheath than that of the latter taxon.

Occurrence: Several collections from the Broken Skull Formation, especially between D375:117 and D555:169.

Material: Oistodiform elements 21, prioniodiform elements 29, ramiform elements 38.

Illustrated Material: GSC50278, GSC50279, GSC50280, GSC50281, GSC50319, GSC50282, GSC50283

## Acodus erectus Pander

(Pl. 3, fig. 4)

Acodus latus Pander, 1856.

Acodus erectus Pander, Klapper *et al.*, 1977, pp. 13, 14, Pl. 3, figs. 1-3 (also see synonymy).

Remarks: Only one acontiodiform element was recovered. This element is identical to that illustrated as Acodus latus Pander, but that form taxon has been included in the multielemental apparatus of *A. erectus*.

Occurrence: One collection from the Road River Formation at Section K (K2020:616).

Material: 1 specimen

Illustrated Material: GSC50881

### *Acodus gladiatus* Lindström s.f.

(Pl. 3, fig. 18)

*Acodus gladiatus* Lindström, 1955 ., p. 544, Pl. 3, figs. 10-12; Lindström, 1957, p. 164.

*Acodus*? *gladiatus* Lindström, emend. Serpagli, 1974, pp. 34, 35, Pl. 7, figs. 10a-c (part.), Pl. 20, figs. 4, 5 (part.).

*Acodus gladiatus* Lindström, Landing, 1976, p. 629, Pl. 1, fig. 7.

*Remarks*: One acodiform element similar to that figured from the Deep Kill Shale of New York by Landing (1976) is referred to the form species *Acodus gladiatus*. The inner lateral costa is less prominent, but bears identical microsculpture. Serpagli (1974) considered this to be a multielement taxon, a view not upheld by Klapper *et al*. (1977).

*Occurrence*: The specimen occurs within the *Oepikodus evae* Zone of the Road River Formation.

*Material*: 1 specimen only

*Illustrated Material*: GSC50890

### Acodus mutatus (Branson and Mehl)

(Pl. 23, fig. 5)

Belodus mutatus Branson and Mehl, 1933, p. 126, Pl. 10, fig. 17.

Acodus mutatus (Branson and Mehl), Bergström and Sweet, 1966, pp. 303-305, Pl. 35, figs. 7, 9 (includes synonymy through 1966); Uyeno, 1974, p. 16, Pl. 1, fig. 23; Barnes, 1977, pp. 104-105, Pl. 3, figs. 4, 5.

Remarks: In the present collection, only the distacodiform element is present. According to Bergström and Sweet (1966, p. 304), the apparatus of Acodus mutatus includes distacodiform and acodiform (acontiodiform) elements. However, Uyeno (1974), in a later study, did not recover any distacodiform elements.

Occurrence: Sporadically in the Esbataottine, Whittaker and Road River formations.

Material: 16 specimens

Illustrated Material: GSC50485

### Acodus sweeti (Serpagli, 1974), emend. Klapper et al., 1977

(Pl. 10, figs. 12, 13)

Paltodus sp. B, Ethington and Clark, 1971, pp. 67, 73, Pl. 2, fig. 13.

Paltodus ? sweeti Serpagli, 1974, p. 58, Pl. 14, figs. 13-14, Pl. 24, figs. 8-10, text-fig. 12.

Acodus sweeti (Serpagli), Klapper et al., 1977, pp. 19, 20, Pl. 3, figs. 7, 8.

Remarks: Klapper et al. (1977) included 'Scandodus' americanus Serpagli in, and suggested Walliserodus australis Serpagli may belong to, the apparatus of P. ? sweeti as its oistodiform and ramiform elements, and designated the taxon as Acodus sweeti. I agree that P. ? sweeti may be an acodid in the sense of Klapper et al. (1977), and that elements of 'Scandodus' americanus probably belong to it (as was also noted by Serpagli, 1974). However, the inclusion of W. australis with the apparatus of A. sweeti is rejected. [For some strange reason, Klapper et al. (op. cit.) have themselves rescinded this in the same study.]

Occurrence: Lower to lower middle part of the Broken Skull Formation.

Material: 12 specimens

Illustrated Material: GSC50056, GSC50284

### Acodus sp. aff. A. numaltipes Schopf s.f.

(Pl. 26, fig. 20)

aff. Acodus numaltipes Schopf, 1966, p. 32, Pl. 5, fig. 17, fig. 7 - c,d,e.

Remarks: A few specimens appear to be similar to the species A. numaltipes Schopf. They possess a long base, a deep conical basal cavity extending to the point of curvature and a low lateral carina. However, the units are less asymmetric than those described by Schopf (1966).

Occurrence: High in the Whittaker Formation at Section D.

Material: 4 specimens

Illustrated Material: GSC50184

## Acodus n. sp. A

(Pl. 2, figs. 10, 11, 15, 16)

Diagnosis: A multielement species with acodiform, ramiform and oistodiform elements. Both acodiform and ramiform elements are characterized by a thin basal sheath.

Description: The acodiform (prioniodiform) element is characterized by a strongly compressed anterior edge and a prominent lateral costa that is poorly developed towards the tip but increases its relief towards the base of the unit, giving the base a twisted appearance. The placement of the lateral costa is similar to that seen in Acodus brevis Branson and Mehl, except that it does not curve downwards (and backwards) as sharply.

The ramiform element is very similar to a flattened version of the prioniodiform element of Acodus deltatus deltatus Lindström. This would mean that lateral costae are less developed. The posterior edge is quite sharp while the anterior edge is a flattened surface. The basal cavity, which is elliptical in outline, appears to be moderately deep. On one side of the lateral face, towards the anterior part, a slight elevation is present.

Two types of oistodiform elements are included here; one of these appears to be identical to Oistodus linguatus extenuatus Lindström s.f. while the other is similar to O. linguatus Lindström s.f. Oistodiform elements of multielemental Acodus species are quite conservative and it is not unusual to find similar oistodiform elements in the apparatus of more than one multielement species.

Remarks: The inclusion of oistodiform elements with the species is primarily on the basis of co-occurrence and similarity in size.

Occurrence: Lower part of the Road River Formation at Section K.

Material: Prioniodiform elements 2, ramiform elements 2, oistodiform elements 6.

Illustrated Material: GSC50028, GSC50871, GSC50872, GSC50029

## Genus Acontiodus Pander, 1856 s.f.

Type species: Acontiodus latus Pander, 1856

Remarks: Following the suggestions of Lindström (1971), most acontiodiform elements are now included under Protopanderodus. Some elements, especially from the Middle Ordovician Midcontinent (e.g. Acontiodus alveolaris Stauffer s.f. and A. lindstroemi Ethington s.f.), that do not possess a sharp posterior costa were recently brought into a new genus Staufferella Sweet et al., 1975. Uyeno (1974) reported a new species, "Acontiodus" sp. A, which can be accommodated within the framework of this Staufferella. One species that is quite common in the Early and Lower Middle Ordovician still being included in this genus is A. robustus Hadding . At present the skeletal apparatus of the type species of Acontiodus is unknown, and the genus is used as a form genus.

### Acontiodus robustus (Hadding) s.f.

(Pl. 7, fig. 8)

Drepanodus robustus Hadding, 1913, p. 31, Pl. 1, fig. 5.

Acontiodus robustus (Hadding). Barnes and Poplawski, 1973, pp. 768, 769, Pl. 2, fig. 15 (source includes synonymy through 1972).

Acontiodus robustus (Hadding), Landing, 1976, pp. 629, 630, Pl. 1, fig. 8.

Remarks: Several specimens from the Road River Formation are identical to the form species Acontiodus robustus. Although surface striations are absent from most specimens, their presence on the elements that co-occur with A. robustus, e.g. Protopanderodus cooperi (Sweet and Bergström) probably suggests that a symmetry transition series may be present between A. robustus on one hand and protopanderodids such as P. gradatus Serpagli and P. cooperi (Sweet and Bergström) at the other ends of the spectrum.

Occurrence: The acontiodiform elements as noted above are present in the Road River Formation K2375:724 and Locality 5. The species appears to be a common constituent of the Early and Lower Middle Ordovician faunas of the North Atlantic aspect.

Material: 15 specimens

Illustrated Material: GSC50318

## Genus Ambalodus Branson and Mehl, 1935 s.f.

Type species: Ambalodus triangularis Branson and Mehl, 1933

Remarks: Ambalodus, a well known Middle and Upper Ordovician form taxon, is regarded as a component of either Eoplacognathus, Amorphognathus or Rhodesognathus. Two questionable ambalodiform elements occurring in the Lower Ordovician are described as form-taxa.

### Ambalodus ? sp. s.f.

(Pl. 8, fig. 3)

Description: A single broken specimen, extremely thin sheathed and rather 'primitive' in appearance, possesses in plan view an elongated, sinuous triangular shape; bearing a row of low, poorly-developed nodes that are offset to one side of the unit. The carina bearing the nodes is sinuous in appearance. The aboral region consists of a deep and narrow cavity underneath the nodes.

Remarks: It is possible that this unit represents a broken portion of either Pygodus ? sp. or some other hollow, thin-sheathed element.

Occurrence: The specimen was present in D555:169, Broken Skull Formation.

Material: 1 specimen

Illustrated Material: GSC50247

## *Ambalodus* ? sp. 1 s.f.

(Pl. 8, fig. 5)

Description: A single specimen representing a primitive platform element having a very thin sheath and a deep flaring basal cavity. In plan view, the unit appears to be leaf shaped. There are no denticles, but a distinct ridge occupies the central part of this element.

Remarks: The presence of platform elements low in the Arenigian is quite rare in North America although they are known to occur in the Baltic Shield.

Occurrence: The specimen was present in the Broken Skull Formation (D555:169).

Material: 1 specimen

Illustrated Material: GSC50248

### Genus *Amorphognathus* Branson and Mehl, 1933

*Type species*: *Amorphognathus ordovicicus* Branson and Mehl, 1933

*Remarks*: This genus has been recently reviewed by Bergström (1971) and is at present regarded as a multielemental genus that includes amorphognathiform and ambalodiform elements. Several other form genera are also listed in the synonymy of *Amorphognathus* (Bergström, 1971, p. 131). Several fragmentary amorphognathid elements occur in the Road River Formation, K2375:724. Also present in the same collection are ambalodiform elements. These are described under the genus *Eoplacognathus* (Hamar) or the genus *Rhodesognathus* Bergström and Sweet. From the younger Middle Ordovician rocks, one multielement species has been recognized in the Road River Formation, *A. superbus* (Rhodes), while another species, *Amorphognathus* sp. A ?, is present in the carbonates of the southern Mackenzie platform.

### Amorphognathus superbus (Rhodes) sensu Bergström

(Pl. 5, figs. 13, 14)

Holodontus superbus Rhodes, 1953, p. 304, Pl. 21, figs. 125-127.

Amorphognathus superbus (Rhodes). Bergström, 1971, p. 135 (under A. ordovicicus), Pl. 2, figs. 8, 9. Klapper et al., 1977, pp. 43-45, Pl. 3, figs. 1-9 (see additional synonomy).

Remarks: Prior to the review by Klapper et al. (1977) confusion existed in the proper concept and designation of this species and its separation from Amorphognathus ordovicicus Branson and Mehl. Bergström (1971) did not include Amorphognathus superbus (Rhodes) in synonymy with A. ordovicicus Branson and Mehl, but stressed the differences between the two species by illustrating differences between their amorphognathiform and holodontiform elements (Bergström noted that A. superbus evolved from A. tvaerensis and was succeeded by A. ordovicicus). Although no holodontiform element was recovered in the collections, the amorphognathiform element is identical to A. superbus, while the accompanying ambalodiform element (A. triangularis) is also present.

Webers (1966) noted that A. ordovicicus (A. superbus sensu Bergström) is invariably associated with Ambalodus triangularis Branson and Mehl. This also appears valid for the present occurrence.

Occurrence: This species was recovered from the Road River Formation at Locality 2. It is an index taxon of late Middle to early Upper Ordovician age, and is generally absent to rare in the Midcontinent faunas.

Material: Amorphognathiform elements 5, ambalodiform elements 5.

Illustrated Material: GSC50902, GSC50903

## Amorphognathus sp. A ?

(Pl. 5, figs. 11, 12; Pl. 26, fig. 19)

Diagnosis: An amorphognathiform, star-shaped element with four lobes and one process diverging from a central point.

Description: The element consists of four lateral lobes that in plan view vary from broadly triangular to blade-like, and possess a central row of subequal and equally spaced denticles or nodes on ridges along the upper surfaces of the lobes. The main process (anterior or posterior) is longer, but carries similar denticles or nodes. A characteristic cellular-type of microsculpture is present. The basal cavity is highly diagnostic as it varies from a narrow furrow beneath the central region which widens outwards (a tendency towards Amorphognathus). Apparently this feature is common in several platform-like conodont elements from the Middle Ordovician of Scandinavia, Wales and southern Appalachians (see Bergström and Sweet, 1966). These latter elements [e.g. Eoplacognathus elongatus (Bergström) and Polyplacognathus ringerikensis Hamar] show some superficial similarity to Polyplacognathus ramosus. The present form bears some resemblance to Eoplacognathus elongatus (Bergström), as illustrated by Bergström and Carnes (1976, p. 32, fig. 2). Tentatively included with this taxon is a keislognathiform element similar to Keislognathus gracilis Rhodes. The two co-occur in the same sample.

Occurrence: Only one specimen of each amorphognathiform and keislognathiform elements is present. These were recovered from the Whittaker Formation, E2440:744.

Material: See above.

Illustrated Material: GSC50183, GSC50901

## Genus *Aphelognathus* Branson, Mehl and Branson, 1951

*Type species*: *Aphelognathus grandis* Branson, Mehl and Branson, 1951 by original designation

*Emended Multielement Diagnosis*: Conodonts with a Type 1 skeletal apparatus of P, $O_1$, N, $A_1$, $A_2$ and $A_3$ elements (Klapper and Philip, 1971). The P element is ozarkodiniform, with a prominent gap in denticle profile immediately anterior to the cusp; the $O_1$ element is dichognathiform in the early species, probably prioniodiniform in later ones; N is prioniodiniform or cyrtoniodiform; $A_1$ is cordylodiform or eoligonodiniform; $A_2$ is zygognathiform; $A_3$ is trichonodelliform (Sweet *et al*., 1975).

*Remarks*: Sweet *et al*. (1975) have redefined this genus and given it a multielemental diagnosis. This is accepted here. However, as was noted by Sweet *et al*., it is extremely difficult to distinguish most elements of *Plectodina* (excepting the P element) from those of *Aphelognathus*, while the P element of *A*. *kimmswickensis* is difficult to separate from *A*. *politus* or *A*. *grandis*, especially if these are fragmentary. In the present study, some of the broken P elements included in *A*. *kimmswickensis* may belong to either *A*. *politus* or *A*. *grandis*.

### *Aphelognathus kimmswickensis* Sweet *et al*.

(Pl. 26, figs. 1, 4, 9)

*Aphelognathus kimmswickensis* Sweet *et al*., 1975, pp. 31, 32, 33, Pl. 2, figs. 18-23.

*Remarks*: I can identify only the P element with confidence, and the $A_2$ and $A_3$ elements with less assurance. These are the ones illustrated. As noted earlier, $A_1$ and N elements are difficult to distinguish from those of *Plectodina furcata* (Hinde), while $O_1$ element, though present, may have been included with *Phragmodus undatus*.

*Occurrence*: Based on the occurrence of the P element, *A. kimmswickensis* is believed to be present in several collections from the Whittaker Formation.

*Material*: There are 45 P elements, 13 $A_3$ elements and 9 $A_2$ elements amongst others.

*Illustrated Material*: GSC50166, GSC50167, GSC50168

### Genus Appalachignathus Bergström *et al.*, 1974

Type species: *Appalachignathus delicatulus* Bergström *et al.*, 1974.

### *Appalachignathus delicatulus* Bergström *et al.*
(Pl. 23, figs. 1-4, 7)

?*Coleodus simplex* Branson and Mehl, Webers, 1966, p. 63, Pl. 4, fig. 5.

*Coleodus* n. sp. Ethington and Schumacher, 1969, p. 458, Pl. 69, fig. 6.

New Genus B Ethington and Schumacher, 1969, p. 479, Pl. 67, fig. 18, text-fig. 4H.

*Appalachignathus delicatulus* Bergström *et al.*, 1974, pp. 228-233, Pl. 1, figs. 1-10, text-fig. 1-3.

Remarks: The skeletal apparatus of this species was fully discussed by Bergström *et al.* (1974) and nothing significant need be added here. It may be noted however that some eoligonodiniform elements from the present collection appear to bear no denticles towards the lower parts (see Pl. 23, fig. 1). One element (Pl. 23, fig. 7) is questionably included here but may be closer to *Coleodus* because of its possible hyaline aspect.

Occurrence: Elements of this species have been recovered from several samples from the Esbataottine Formation. The complete apparatus however was only recovered from one collection (P1730:527). The species is generally regarded as an important stratigraphic taxon indicating late Chazyan to early Blackriveran age. Its stratigraphic distribution has been discussed in detail by Bergström et al. (1974).

Material: Trichonodelliform elements 5, zygognathiform elements 4, eoligonodiniform elements 3, ozarkodiniform and spathognathodiform elements 32.

Illustrated Material: GSC50143, GSC50148, GSC50152, GSC50149, GSC50484

## Genus Belodella (Ethington), 1959

Type species: Belloda devonica (Stauffer), 1940

Remarks: Contrary to Cooper (1974), Ordovician occurrences of Belodella have been held valid since Serpagli (1967) supported its occurrence in the Ordovician. Barnes and Poplawski recently (1973) suggested that Belodella includes two components, one denticulate and one essentially drepanodiform. Votaw (1971), in an unpublished study, recognized a form transition series in belodelliform elements (and also included one oistodiform element). Some of the oistodiform elements described under Oistodus nevadensis Ethington and Schumacher may belong here. The two species recognized here are similar to two previously described species, B. erecta (Rhodes and Dineley) and B. n. sp. Barnes and Popławski.

### Belodella erecta (Rhodes and Dineley)

(Pl. 23, figs. 10-12)

Belodus erectus Rhodes and Dineley, 1957, p. 359, Pl. 38, fig. 8.

Belodella erecta (Rhodes and Dineley). Barnes and Poplawski, 1973, p. 769, Pl. 4, figs. 19, 20 (includes synonymy to 1973).

Belodella n. sp. s.f. Barnes, 1974, Pl. 1, fig. 11.

Belodella erecta (Rhodes and Dineley), Barnes, 1977, p. 101, Pl. 2, fig. 7.

Remarks: Barnes (1977) suggested that a transition series exists within elements previously referred to Belodella erecta, namely of the cordylodiform, zygognathiform and trichonodelliform type. In this context, one element included here, the drepanodiform element with a slight apical twist and poorly developed oral denticles, may represent the zygognathiform element of this taxon (see Pl. 23, fig. 11).

Occurrence: Late Chazy and early Blackriver part of the Sunblood Formation from Sections A and P.

Material: 17 specimens

Illustrated Material: GSC50490, GSC50491, GSC50153

### *Belodella* sp. aff. *B.* n. sp. s.f. Barnes and Poplawski

(Pl. 6, figs. 13-15)

aff. *Belodella* n. sp. s.f. Barnes and Poplawski, 1973, pp. 769, 770, Pl. 4, figs. 5, 9, 10, 18, 18a, text-fig. 2F.

aff. *Belodella* n. sp. s.f. Barnes, 1977, p. 101, Pl. 2, figs. 5, 6.

*Remarks*: This species differs from *B.* n. sp. Barnes and Poplawski, 1973, in two respects:

(a) the former has more prominent minute hair-like dentitions on the posterior margin.

(b) the lateral costae in the plano-convex elements are more continuous and begin near the tip of the cusp, fading out towards the bases of the units.

The age of *B.* sp. aff. *B.* n. sp. is younger than the *Belodella* species described by Barnes and Poplawski (1973).

*Occurrence*: From the Road River Formation at Locality 5.

*Material*: 5 specimens

*Illustrated Material*: GSC50237, GSC50236, GSC50914

### Genus Belodina Ethington, 1959

Type species: Belodina compressa (Branson and Mehl, 1933) = Belodus grandis Stauffer, 1935b, designated by Ethington (1959) as type of Belodina

Remarks: Belodina appears to have the dubious distinction of being regarded as both a multielemental and monoelemental genus. Bergström and Sweet (1966) suggested that B. compressa is the only known multielemental species of this genus, containing an eobelodiniform element together with a belodiniform element in its apparatus. However, Ethington and Schumacher (1969) and Barnes (1977) amongst others have either suggested or included eobelodiniform and belodiniform elements in the apparatuses of other Belodina species. Barnes (1967) illustrated a cluster of Belodina.

### *Belodina compressa* (Branson and Mehl)

(Pl. 23, figs. 9, 14, 15, 17)

*Belodus compressus* Branson and Mehl, 1933, p. 114, Pl. 9, figs. 15, 16.

*Belodina compressa* (Branson and Mehl), Bergström and Sweet, 1966, pp. 312-315, Pl. 31, figs. 12-19; Weyant, 1968, pp. 36, 37, Pl. 2, fig. 6 (belodiniform element); Sweet, Ethington and Barnes, 1971, p. 173, Pl. 2, figs. 27, 28; Moskalenko, 1972, pp. 52, 53, figs. 7-3 and 7-4 only; Moskalenko, 1973, pp. 56, 57, Pl. 5, figs. 3-6 (belodiniform element); Uyeno, 1974, p. 15, Pl. 1, figs. 10-13; Barnes, 1977, p. 105, Pl. 4, figs. 16-18.

*Belodina grandis* (Stauffer), Weyant, 1968, p. 38, Pl. 2, fig. 1 (belodiniform element).

?*Belodina dispansa* (Glenister), Weyant, 1968, p. 37, Pl. 2, figs. 2, 3 (belodiniform element).

*Eobelodina fornicala* (Stauffer), Weyant, 1968, pp. 49, 50, Pl. 2, fig. 7 (eobelodiniform element); Moskalenko, 1973, pp. 34, 35, Pl. 1, figs. 5, 6 (eobelodiniform element).

*Remarks*: In the present collection, the belodiniform eobelodiniform ratio is high variable. A similar variation was noted earlier by Moskalenko (1972).

*Occurrence*: Sporadically distributed throughout the Chazyan to Kirkfieldian interval of the Sunblood, Esbataottine and Whittaker formations.

*Material*: Belodiniform elements 146, eobelodiniform elements 36.

Illustrated

Material: GSC50715, GSC50488, GSC50489, GSC50128

Belodina moniterensis marginata Ethington and Schumacher

(Pl. 6, fig. 10; Pl. 7, fig. 12)

Belodina moniterensis marginata Ethington and Schumacher, 1969, p. 456, Pl. 67, figs. 1, 2, 4, 6; text-fig. 5E (see synonymy).

Eobelodina occidentalis Ethington and Schumacher, 1969, pp. 462, 463, Pl. 67, figs. 16, 20; text-fig. 5H.

Remarks: Ethington and Schumacher (1969) distinguished between the two subspecies B. moniterensis moniterensis and B. moniterensis marginata primarily on the strongly developed occurrence of lateral costae in B. moniterensis moniterensis and its absence in B. moniterensis marginata. Further, while describing the species Eobelodina occidentalis, they noted that it may be the eobelodiniform element of B. moniterensis. The co-occurrence of the two form species B. moniterensis marginata and E. occidentalis in the study area lends some credence to this. My material is too sparse to comment on the taxonomic status of the two subspecies, B. moniterensis moniterensis and B. moniterensis marginata. However, I feel justified in including E. occidentalis as the eobelodiniform element of this taxon.

Occurrence: Road River Formation at Locality 5.

Material: Belodiniform elements 2, eobelodiniform element 1.

Illustrated Material: GSC50238, GSC50242

## Belodina sp. aff. B. inclinata (Branson and Mehl) s.f.

(Pl. 26, fig. 15)

aff. Belodus inclinatus Branson and Mehl, 1933, pp. 125, 126, Pl. 10, fig. 24.

aff. Belodina inclinata (Branson and Mehl), Schopf, 1966, p. 43, Pl. 1, figs. 2, 9.

Remarks: The element is asymmetrical, with a grooved outer face and a nearly flat inner face. It shows some similarity to B. inclinata (Branson and Mehl) sensu Schopf, 1966.

Occurrence: Rare in the Whittaker Formation (E2740:835).

Material: 2 specimens

Illustrated Material: GSC50180

### Genus Bryantodina Stauffer, 1935a

Type species: Bryantodina typicalis Stauffer, 1935a

Remarks: Bergström and Sweet (1966) suggested that the apparatus of this genus consists of prioniodiform and bryantodiniform elements. Only the bryantodiniform elements were recovered in this study.

### Bryantodina ? abrupta (Branson and Mehl)

(Pl. 26, fig. 17)

Ozarkodina (?) abrupta Branson and Mehl, 1933, p. 100, Pl. 6, fig. 11.

Bryantodina ? abrupta (Branson and Mehl), Bergström and Sweet, 1966, pp. 318-321, Pl. 30, figs. 9-12, text-fig. 8A-D; Sweet, Ethington and Barnes, 1971, p. 173, Pl. 2, fig. 36 (bryantodiniform element), Uyeno, 1974, p. 17, Pl. 1, figs. 20, 22.

Bryantodina abrupta (Branson and Mehl), Schopf, 1966, pp. 44, 45, Pl. 4, figs. 13, 14; Globensky and Jauffred, 1971, p. 54, Pl. 2, fig. 11 (bryantodiniform element).

Remarks: The prioniodiform element appears to be absent.

Occurrence: Whittaker Formation at Section E.

Material: 12 specimens

Illustrated Material: GSC50181

## Genus *Chirognathus* Branson and Mehl, 1933

*Type species*: *Chirognathus monodactylus* Branson and Mehl, 1933

*Remarks*: *Chirognathus* was established as a form genus by Branson and Mehl (1933) for fibrous conodont elements that consist of palm-shaped units with denticles of varying length. Webers (1966) suggested that all of the form-species of *Chirognathus*, *C*. *admirandus*, *C*. *delicatulus*, *C*. *multidens* and *C*. *monodactylus*, probably belonged to the same skeletal apparatus. He therefore placed them in an informal group. In an unpublished study Votaw (1971), as well as Sweet and Bergström (1972), suggested that this informal group be referred to as *Chirognathus monodactylus*. This is accepted and followed here. This is also borne out from the small collection at hand. The elements are part of a transition series. Two additional chirognathiform elements are described as form taxa.

### *Chirognathus monodactylus* Branson and Mehl

(Pl. 25, figs. 7, 11)

*Chirognathus monodactyla* Branson and Mehl, 1933, pp. 29, 31, Pl. 2, figs. 11, 13; Fay, 1952, p. 80; Sweet, 1955, p. 239, Pl. 27, fig. 20; Webers, 1966, pp. 55, 56, Pl. 5, fig. 5.

*Chirognathus multidens* Branson and Mehl, 1933, p. 34, Pl. 2, fig. 43; Fay, 1952, p. 79; Sweet, 1955, pp. 235, 236, Pl. 27, fig. 15; Webers, 1966, p. 54, Pl. 5, fig. 3.

*Chirognathus* sp. cf. *multidens* Branson and Mehl, Atkinson, 1971, Pl. 4, fig. 7.

*Chirognathus admiranda* Stauffer, 1935a, p. 135, Pl. 9, figs. 6, 16, 22; Fay, 1952, p. 79; Sweet, 1955, pp. 235, 236, Pl. 27, fig. 15; Webers, 1966, p. 54, Pl. 5, fig. 3.

*Chirognathus alternatus* Stauffer, 1935a, pp. 135, 158, Pl. 9, fig. 31.

*Chirognathus delicatulus* Stauffer, 1935a, pp. 136, 158, Pl. 9, figs. 1-3, 5, 7-13, 17-19, 21; Fay, 1952, p. 79; Sweet, 1955, p. 237, Pl. 27, pp. 136, 137, Pl. 15, fig. 6; Sweet *et al.*, 1971, Pl. 2, fig. 16; Atkinson, 1971, Pl. 4, figs. 11, 14, 15.

*Chirognathus eucharis* Stauffer, 1935a, pp. 136, 158, Pl. 9, figs. 28, 29, 34; Fay, 1952, p. 80; Sweet, 1955, p. 238, Pl. 27, fig. 17.

?*Chirognathus duodactylus* Stauffer, 1935a, pp. 136, 158, Pl. 9, fig. 29.

*Chirognathus expatiatus* Stauffer, 1935a, pp. 137, 158, Pl. 9, fig. 4; Fay, 1952, p. 80.

*Chirognathus idoneus* Stauffer, 1935a, pp. 137, 158, Pl. 9, fig. 24; Fay, 1952, p. 80; Sweet, 1955, pp. 238, 239, Pl. 27, figs. 8, 16.

*Chirognathus hamatus* Stauffer, 1935a, pp. 137, 158, Pl. 9, fig. 33; Fay, 1952, p. 80.

Chirognathus irregularis Stauffer, 1935a, pp. 137, 138, 158, Pl. 9, fig. 32; Fay, 1952, p. 80.

Chirognathus lanesboroensis Stauffer, 1935a, pp. 138, 158, Pl. 9, fig. 14; Fay, 1952, p. 80.

Chirognathus magnificus Stauffer, 1935a, pp. 135, 158, Pl. 9, fig. 25; Fay, 1952, p. 80.

Chirognathus radiatus Stauffer, 1935a, pp. 139, 158, Pl. 9, fig. 15; Fay, 1952, p. 80.

Chirognathus unguliformis Stauffer, 1935a, pp. 139, 158, Pl. 9, fig. 41; Fay, 1952, p. 81; Sweet, 1955, p. 242, Pl. 27, fig. 21.

Chirognathus scalenus Stauffer, 1935a, pp. 140, 158, Pl. 9, figs. 30, 37, 38; Fay, 1952, p. 85.

Remarks: All elements of Chirognathus monodactylus are generally small but equivalent in size, completely hyaline, and co-occur in a single collection, P1405:428, from the Sunblood Formation.

Material: 24 specimens

Illustrated Material: GSC50518, GSC50519

### *Chirognathus* n. sp. 1 s.f.

(Pl. 25, fig. 8)

**Description:** A chirognathiform element shaped like a half-closed palm. The basal opening is almost quadrilateral with smoothly curved sides. The cavity is very shallow. The denticles are fused together basally; are subequal; and are seen only near the top of the unit. The unit has a smooth surface. It is unlike any other previously described *Chirognathus*.

**Occurrence:** Sunblood Formation at Section P (P1405:428).

**Material:** 1 specimen

**Illustrated Material:** GSC50139

### Chirognathus ? sp. s.f.

(Pl. 6, fig. 7)

Description: This hyaline unit has an outline intermediate between that of a trucherognathiform and a curtognathiform element. All denticles except the 'anteriormost' lean towards one end. The thickness of the denticles and the degree of leaning increases 'posteriorly'. A narrow slit-like aboral opening is present. The 'anteriormost' denticle is almost erect. The compressed shape and arrangement of the denticles is reminiscent of Chirognathus.

Occurrence: Road River Formation, Locality 5.

Material: 2 specimens

Illustrated Material: GSC50910

## Genus Clavohamulus Furnish, 1938 s.f.

Type species: Clavohamulus densus Furnish, 1938

Remarks: Miller (1969) has redefined this genus to include forms that may lack a cusp entirely. A bilateral symmetry, an abrupt expansion of the basal portion and an unusually reduced basal cavity are the diagnostic features of this genus. The stratigraphic occurrence is low in the Lower Ordovician (Miller, 1976). Its occurrence in late Canadian rocks of the Broken Skull Formation suggests an extension of the upper limit.

### Clavohamulus n. sp. 1 s.f.

(Pl. 16, fig. 5)

Diagnosis: A robust clavohamulid with a minute cusp widening rapidly and then tapering into a flask-shaped unit that has a narrow aboral surface. The entire unit is highly ribbed.

Description: Unit thickest upward. Element widest (laterally) at a level near the top of the unit. Toward the top, the unit tapers backwards (with convex outward margins) to a sharply rounded and slightly upturned oral tip. Below the widest point, the unit tapers (with relatively parallel margins) to a bluntly rounded aboral termination. The basal cavity is very shallow. The unit possesses at least seven well-developed costae arranged laterally and antero-laterally. The space between the costae appears as deep grooves. The costae begin near the top of the unit, immediately below or at the same level as the tiny cusp, and continue downwards. However, they do not meet the aboral margin. The posterior face, immediately below the tip of the cusp, is curved inwards and possesses several longitudinal costae that are considerably less prominent than the lateral or antero-lateral costae.

Remarks: This form-species is unlike any described form of *Clavohamulus*. The tiny cusp attached to an enlarged bulbous base allows me to place this form in *Clavohamulus* with confidence.

Occurrence: Upper part of the Broken Skull Formation.

Material: 3 specimens

Illustrated Material: GSC50372

## Genus Coelocerodontus Ethington, 1959

Type species: Coelocerodontus trigonius Ethington, 1959

Remarks: Jones (1971) regarded Proconodontus Miller to be a junior synonym of Coelocerodontus. However, Klapper et al. (1973) pointed out that Proconodontus is "more robust, and has a wider basal cavity." They also point out that the two genera differ widely in time. Chatterton (1974) has discussed some aspects of this genus and its probable relationship with Belodella. I have treated this genus as a multielement taxon.

## Coelocerodontus n. sp. A

(Pl. 9, figs. 1, 2)

Diagnosis: Large simple cones showing a symmetry transition from open, hollow, noncostate, bilaterally symmetrical forms to laterally compressed units with strong posterior and anterior keels. Basal sheath is very thin.

Description: The open forms are bilaterally symmetrical, with a sharp posterior costa and a rounded anterior margin. Basal opening varies from subrounded to elliptical. The entire unit is very hollow. Faint traces of transverse ridges are present.

The compressed forms are asymmetrical, with one of the lateral faces being plane to convex while the other showing an almost concave outline. The basal region is laterally flared and is usually wide compared to the compressed upper half. Both anterior and posterior margins are strongly costate though the lateral faces are very smooth.

Occurrence: Several collections from the Broken Skull Formation especially common in D375:117.

Material: Compressed elements 2, open elements 14.

Illustrated Material: GSC50259, GSC50260

### Genus Cordylodus Pander, 1856 emend. Barnes and Poplawski, 1973

Type species: Cordylodus angulatus Pander

Remarks: As emended by Barnes and Poplawski (1973), Cordylodus is regarded here as a multielemental genus whose apparatus in the Tremadocian included only cordylodiform elements. In younger rocks, it comprises a symmetry transition series that includes cordylodiform elements, ligonodiform, cladognathiform and hibbardelliform variants. Similar views were also expressed by Lindström (1964).

## Cordylodus proavus Müller s.f.

(Pl. 2, figs. 6, 7, 9)

Cordylodus proavus Müller, 1959, p. 448, Pl. 15, figs. 11, 12, 18, text-fig. 3B; Miller, 1969, p. 424, Pl. 65, figs. 37-45; Druce and Jones, 1971, p. 70, Pl. 1, figs. 1a,b, text-fig. 23p,q,r; Jones 1971, p. 48, Pl. 2, figs. 9a-c; Miller and Melby, 1971, p. 120, Pl. 1, figs. 18-19; Müller, 1973, p. 35, Pl. 9, figs. 1, 2, 3a,b, 4-9, text-fig. 2A.

Remarks: This is the most primitive representative of the genus. It has a very large triangular basal cavity, which in the more advanced elements of the species becomes smaller, with the sides becoming planar and then concave (see Druce and Jones, 1971, fig. 23). The cross section of the main denticle may be rounded or sharply edged at both sides; transitions between these forms have been observed in the same collection.

Occurrence: Nominate species of the Cordylodus proavus Zone, K880:268.

Material: 23 specimens

Illustrated Material: GSC50868, GSC50008, GSC50869

## Cordylodus ramosus Hadding

(Pl. 4, fig. 7)

Cordylodus ramosus Hadding, 1913, p. 31, Pl. 1, fig. 6; Sweet and Bergström, 1962, p. 1225, Pl. 170, fig. 15, Pl. 171, fig. 10 (includes synonymy through 1961); Lindström, 1964, fig. 27D; Barnes and Poplawski, 1973, p. 772, Pl. 4, fig. 6.

Polygnathus spinatus Hadding, 1913, p. 32, Pl. 1, fig. 8.

Cordylodus spinatus (Hadding), Lindström, 1955a, Pl. 22, figs. 5, 18, 27; Uyeno and Barnes, 1970, pp. 106-107, Pl. 24, figs. 7-11 (includes synonymy through 1968).

Cordylodus sp. Bradshaw, 1969, pp. 1148-1149, Pl. 135, fig. 14.

Cordylodus ? sp. Bradshaw, 1969, p. 1149, Pl. 135, fig. 13.

Remarks: Lindström (1964), Uyeno and Barnes (1970) and Barnes and Poplawski (1973) have reviewed this species and nothing need be added here except that only the elements conforming to the morphology of C. ramosus s.f. are present.

Occurrence: Road River Formation at Section K (K2375:724)

Material: 9 specimens

Illustrated Material: GSC50208

### *Cordylodus* sp. aff. *C. horridus* Barnes and Poplawski

(Pl. 18, figs. 3, 5)

aff. *Cordylodus horridus* Barnes and Poplawski, 1973, pp. 771, 772, Pl. 2, figs. 16-18; Landing, 1976, p. 631, Pl. 1, fig. 11.

Remarks: This species differs from *C. horridus* s.s. in two ways: (a) the large denticle immediately follows the main cusp and is usually directed away from it, and (b) the secondary denticles are less discrete and more basally confluent (this latter feature is shown only by the posteriormost of the secondary denticles in *C. horridus* s.s.). As described by Barnes and Poplawski, sinuosity develops in some elements. In the present form, sinuosity is a fixed attribute. The analogy with *Phragmodus* is obvious (also noted by Barnes and Poplawski).

Occurrence: From collection at Section S which is of Whiterockian age.

Material: 6 specimens

Illustrated Material: GSC50412, GSC50413

## Cordylodus sp. s.f.

(Pl. 2, fig. 8)

Remarks: Two cordylodids, that have the main cusp broken, may belong to C. oklahomensis because they have an extended posterior bar (which is different from C. proavus) and denticles which are sharply compressed and slightly twisted.

Occurrence: Occur in Cordylodus proavus Zone (K880:268) of the Rabbitkettle Formation.

Material: 2 specimens

Illustrated Material: GSC50870

## Genus *Curtognathus* Branson and Mehl, 1933

*Type species:* *Curtognathus typus* Branson and Mehl, 1933

*Remarks:* Andrews (1967) provided a detailed discussion on the taxonomic status of several Middle Ordovician 'Fibrous' genera. These included *Cardiodella*, *Curtognathus*, *Erismodus*, *Microcoelodus*, *Polycaulodus* and *Ptiloconus*. He suggested that *Erismodus*, *Microcoelodus* and *Ptiloconus* were congeneric; and several species previously identified as form-taxa were reduced by him to relatively few species.

Votaw (1971), in an unpublished study, further revised and/or refined some of Andrews's conclusions. He pointed out that the genera *Erismodus*, *Microcoelodus* and *Ptiloconus* are not congeneric in the sense of Andrews, but rather are part of a transition series (the *Cordylodus*-*Roundya* series). Moreover, he grouped several *Erismodus* species recognized by Andrews into one, *E. radicans* (Hinde), on the basis of priority [this included two of Andrews's species that were based on geometric changes through time (*E. symmetricus* and *E. asymmetricus*); Votaw disagreed with this conclusion].

Although Votaw (1971) was right in criticising Andrews (1967) for overlooking the basis of priority in the case of *Erismodus radicans*, he was clearly at fault for not explaining more fully his reasons for unifying the four *Erismodus* species of Andrews, *E. typus*, *E. symmetricus*,

E. asymmetricus, and E. gracilis, into one, namely E. radicans.

An unfortunate aspect of identifying more precisely the different elements involved is their highly intergradational nature [for instance, elements identified as E. symmetricus contain both symmetric and slightly asymmetric elements (cf. E. asymmetricus), while the criteria for distinguishing E. asymmetricus from E. gracilis also appear to be highly tenuous (in the latter form, the lateral process is reduced)].

A precise synonymy is impossible to construct and the synonymy attempted is only partial, based on the identification of the four form species involved, namely, E. symmetricus and E. typus (roundyaform, erismodiform elements), E. asymmetricus (zygognathiform, microcoelodiform elements) and E. gracilis (cordylodiform, ptiloconiform elements). Because of the difficulty of distinguishing between these species they have been grouped together as Erismodus spp. Votaw recognized another transition series that included the form genera Cardiodella, Polycaulodus, Trucherognathus and Curtognathus (similar views were also expressed by Sweet and Schönlaub, 1975). I feel however that Votaw (1971) did not explain adequately his reasons for including different elements of these four form genera under one multielement species, Curtognathus typus (except for the fact that most of the elements included by him were noted to have a recurrent association). In an earlier paper, Andrews (1967) had already noted the intergradational nature of three of these genera (with the possible exception of Polycaulodus) prior to the advent of multielement taxonomy. Andrews (op. cit.) separated Polycaulodus from the rest on the basis of its possessing one conspicuous, large denticle laterally flanked on one or both sides by progressively smaller denticles. This in itself may represent some sort of a transitional series. Polycaulodus is therefore excluded from the other three form genera noted above. The multielement species Curtognathus typus is believed to include the following form species: Curtognathus typus, Trucherognathus distorta and Cardiodella tumidus [based in part on Andrews (1967) and Votaw (1971)].

### Curtognathus typus Branson and Mehl s.l.

(Pl. 25, figs. 14, 17, 20)

Curtognathus typus Branson and Mehl, 1933, p. 87, Pl. 5, fig. 28; Branson, p. 69, Pl. 10, fig. 50; Hass, 1962, p. 53, fig. 32-3; Lindström, 1964, p. 145, fig. 49g; Andrews, 1967, pp. 887, 888, Pl. 113, figs. 4, 21; Pl. 114, fig. 22 (additional synonymy till 1967); Atkinson, 1971, Pl. 4, fig. 8.

Trucherognathus distorta Branson and Mehl, 1933, p. 84, Pl. 5, fig. 1; Branson and Mehl, 1943, p. 385, Pl. 64, figs. 30, 33; Branson, 1944, p. 72, Pl. 10, fig. 1; Branson and Mehl, 1944, in Shimer and Shrock, p. 239, Pl. 93, figs. 2, 3; Hass, 1962, p. 46, fig. 24-4; Lindström, 1964, p. 145, fig. 94f; Andrews, 1967, p. 900, Pl. 112, fig. 20, Pl. 113, figs. 10, 25; Atkinson, 1971, Pl. 4, fig. 10.

Cardiodella tumidus Branson and Mehl, 1944, in Shimer and Shrock, p. 239, Pl. 93, figs. 17, 18; Hass, 1962, p. 56, fig. 34-2a,2b; Lindström, 1964, p. 145, fig. 49h; Andrews, 1967, pp. 886, 887, Pl. 112, fig. 12, Pl. 114, figs. 1, 2, 6.

Occurrence: Sporadically through the Chazyan and Lower Blackriveran collections from the Sunblood and Esbataottine formations.

Material: Over 137 specimens, but very fragmentary. Approximate breakdown: trucherognathiform elements 62, cardiodelliform elements 54, curtognathiform elements 11. Distinction between broken elements of these three forms is very difficult.

Illustrated Material: GSC50521, GSC50524, GSC50131

## Genus *Cyrtoniodus* Stauffer, 1935 s.f.

Type species: *Cyrtoniodus complicatus* Stauffer, 1935

Remarks: As noted by Sweet and Bergström (1972), *Cyrtoniodus* probably represents one of the elements of either *Phragmodus* or *Plectodina*. The latter are multielement genera. However, occasionally cyrtoniodiform elements are not easy to place within the multielement framework. Two such elements are included here and are treated as form taxa.

### *Cyrtoniodus* sp. 1 s.f.

(Pl. 24, fig. 9)

Remarks: This element has a gross morphology similar to '*Cyrtoniodus*' sp. of Ethington and Schumacher (1969). Except for the presence of a reduced basal cavity, the description of these authors can be used for the element at hand (Ethington and Schumacher, 1969, p. 479). The stratigraphic level also appears to be the same.

Occurrence: Late Chazy collection from Section A (A190:67).

Material: 1 specimen

Illustrated Material: GSC50504

## Cyrtoniodus sp. 2 s.f.

(Pl. 24, fig. 10)

Remarks: This form is similar to Subcordylodus paratus Stauffer (1935a) as far as the cusp-to-base mode of attachment is concerned. The element has a very distinctive cusp that is widest in the middle and tapers towards the apical end to produce a bluntly rounded tip towards the distal end and almost straight towards the base. Near the base, the cusp is deflected backwards and has a prominent keel that extends to its middle. The lower two-thirds of the inner lateral face of the cusp is raised.

The posterior process carries three denticles that appear to have been closely packed. The basal opening is triangular with a flare under the cusp.

Occurrence: Late Chazy collection from Section A (A190:67).

Material: 1 specimen

Illustrated Material: GSC50505

### Genus Distacodus Hinde, 1879

Type species: Machairodus incurvus Pander, 1856

Remarks: Sweet and Bergström (1972) suggested that this genus represents a drepanodiform element of a bi-elemental apparatus such as Drepanoistodus. The original definition of this genus, however, includes an element with a possible acontiodiform outline (see Lindström, 1955, p. 554). As noted therein, the main criterion appears to be the presence of a lateral costa (or carina) that may or may not be symmetrically placed on either side of the cusp. It was noted by Barnes in Workum et al. (1976) that in the species Scandodus ungavensis Barnes, a symmetry transition exists that includes drepanodiform, acodiform and distacodiform elements. Similar symmetry transition is also suspected for some elements that occur within the Whiterockian collections of this study. They are referred to as Distacodus n. sp. A.

## *Distacodus* n. sp. A

(Pl. 18, fig. 19; Pl. 20, figs. 17, 19, 20)

aff. *Oistodus akpatokensis* Barnes in Workum *et al*., 1976, pp. 173, 174, Pl. 4, figs. 8-12.

aff. *Drepanodus parallelus* Branson and Mehl *sensu* Barnes in Workum *et al*., 1976, p. 171, Pl. 4, fig. 3.

aff. *Scandodus ungavensis* Barnes in Workum *et al*., 1976, pp. 175, 176, Pl. 4, figs. 15-17 only.

*Diagnosis*: Elements of the taxon show a symmetry transition that includes drepanodiform elements (aff. *D. parallelus sensu* Barnes in Workum *et al*., 1976), 'oistodiform' elements (aff. homologous elements of *Oistodus akpatokensis* and/or *Scandodus ungavensis*) and distacodiform elements (aff. homologous elements of *S. ungavensis* or *O. akpatokensis*).

*Remarks*: Barnes (1977) expressed the opinion that elements of the two taxa, *S. ungavensis* and *O. akpatokensis*, may belong to a single multielement taxon. This feeling is shared by me because these elements tend to co-occur in the same collections, have approximately the same size, and possess shapes that match the symmetry transition. Also present in the same collections are drepanodiform elements of the *D. parallelus* type. The different elemental morphologies displayed by this taxon are similar to those shown by *Triangulodus* Van Wamel, 1974.

Of the various components of *Distacodus* n. sp. A, the 'oistodiform' and drepanodiform elements are most similar to those described and illustrated by Barnes (op. cit.), while the acodiform and distacodiform elements are slightly different from those described by Barnes in Workum et al. (1976). The differences are:

(a) the posterior portion of the base is usually not extended in the manner noted by Barnes;
(b) the elements appear to be more strongly recurved;
(c) the elements possess lateral costae that are not continuous throughout the unit, but disappear close to the base, or are turned backwards distally.

Occurrence: Sporadically throughout the Whiterockian collections (Faunas 2?, 3 and 4) from the Sunblood Formation.

Material: Drepanodiform elements 17, 'oistodiform' elements 21, distacodiform elements 21.

Illustrated Material: GSC50418, GSC50450, GSC50104, GSC50451

### Genus Drepanodus Pander, 1856

Type species: Drepanodus circuatus Pander, 1856

Remarks: Following the emended diagnosis of this genus (Klapper et al., 1973) to include simple conodonts with apparatuses consisting of drepanodiform and oistodiform elements, the treatment of drepanodiform elements (without oistodiform counterparts) in the Late Cambrian has become problematic. The poor preservation of the material under study has added to this problem. Elements that cannot be grouped into Proconodontus Miller, but have drepanodiform outlines, are grouped into 'Drepanodus' as per the original diagnosis of "curved, pointed teeth, with anterior and posterior equally big sharp keels and convex, smooth symmetrical lateral surfaces" (quoted in Klapper et al., 1973). Other drepanodids are described under Drepanodus.

### *Drepanodus arcuatus* Pander

(Pl. 11, figs. 1-11, 16-17)

*Drepanodus arcuatus* Pander. Serpagli, 1974, pp. 43, 44, Pl. 8, figs. 8a-10b, Pl. 20, figs. 13-15 (synonymy through 1973); Van Wamel, 1974, pp. 61, 62, Pl. 1, figs. 10-13 (includes new form taxa synonymy); Landing, 1976, p. 632, Pl. 1, figs. 16-19, 21-23.

*Remarks*: This species contains the form taxa *Drepanodus arcuatus* Pander, *Acontiodus arcuatus* Lindström, and *Scandodus pipa* Lindström. The two former taxa have been termed the "arcuatiform element" (Landing, 1976) and the latter the "pipaform element" by Van Wamel (1974). Van Wamel (op. cit.) also included the "graciliform element" [*Drepanodus* ? *gracilis* (Branson and Mehl)] and "sculponeaform element" (*Drepanodus sculponea* Lindström). This latter form was also included by Serpagli (1974). Elements of *Drepanodus* ? *gracilis* are also present in Serpagli's collection which provides some support for Van Wamel's inclusion of this species in *D. arcuatus*. The "sculponeaform" elements from my collection are difficult to separate from "pipaform."

One of the elements ("ulrichodiniform"?) included here has a characteristic anterior notch above the aboral margin. The element is otherwise identical to the 'arcuatiform' element. The anterior notch (groove) is highly reminiscent of the genus *Ulrichodina* Furnish, but the cusp bears no resemblance to that genus. Van Wamel

(1974) has noted the presence of an indentation in the aboral margin of some suberectiform elements of Drepanoistodus numarcuatus. I am not sure whether this feature is similar to that noted in my collections, as he does not provide any illustrations. Some of the drepanodiform elements belonging to Paroistodus parallelus, especially one illustrated by Viira [1974, p. 32, fig. 15 (in Russian)], from the variations within form species Drepanodus proteus Lindström, do show this feature. However, the outline of the cusp in the present species is closer to Drepanodus arcuatus.

Occurrence: Elements of D. arcuatus are present in great numbers throughout the Broken Skull Formation and to a lesser extent in the Road River Formation. These latter forms are treated as sensu lato.

Material: Arcuatiform elements 72, graciliform elements 48, pipa + sculponeaform elements 21, ulrichodiniform ? elements 22 (over 100 additional broken elements).

Illustrated Material: GSC50292, GSC50293, GSC50294, GSC50295, GSC50296, GSC50297, GSC50298, GSC50299, GSC50300, GSC50301, GSC50302, GSC50303, GSC50304

### *Drepanodus* sp. aff. *D.* sp. Sweet and Bergström s.f.

(Pl. 9, fig. 3)

aff. *Drepanodus* sp. Sweet and Bergström, 1962, pp. 1226, 1227, Pl. 168, fig. 17.

*Remarks*: This element differs from *Drepanodus* sp. Sweet and Bergström, 1962, in three ways:

(a) There is less twisting of the base with respect to the cusp.

(b) The posterior margin is straighter.

(c) Near the tip of the basal cavity a conspicuous carina develops.

In other respects, the specimen is identical to *D.* sp. Sweet and Bergström.

Barnes and Poplawski (1973) included *D.* sp. Sweet and Bergström in their species *Scandodus mysticus*.

The element at hand can qualify as the drepanodiform variant of *Scandodus mysticus*.

*Occurrence*: Broken Skull Formation, sample D288:88.

*Material*: 1 specimen

*Illustrated Material*: GSC50261

## Drepanodus sp. s.f.

(Pl. 9, fig. 4)

Description: The cusp is almost straight to erect, with smooth, flat, lateral faces and sharp margins. The posterior margin gently curves to melt the oral edge of the base at a high angle. The anterior margin meets the aboral margin at an acute angle so as to appear extended into an anticusp. The basal opening is elongated (stretched) anteriorly, while the basal cavity is very deep and extends to about half the length of the cusp. The element is almost translucent and has a light grey colour.

Occurrence: Broken Skull Formation, Section D.

Material: 4 specimens

Illustrated Material: GSC50045

### Drepanodus sp. ?

(Pl. 1, fig. 18)

Remarks: Only a single specimen is present which is similar to Drepanodus simplex sensu Druce and Jones, except that the cusp is less wide compared to the latter taxon. Druce and Jones (1971) noted the common occurrence of this species with Acanthodus uncinatus, but stated that D. simplex occurs earlier than A. uncinatus.

Occurrence: Upper part of the Rabbitkettle Formation (K995:303).

Material: 1 specimen

Illustrated Material: GSC50862

### '*Drepanodus*' spp. s.f.

(Pl. 27, fig. 5)

Remarks: Several elements conform to a drepanodid outline. They appear to have a deep basal cavity and little if any white matter (see discussion above). However, their poor state of preservation is not helpful in this regard.

Occurrence: Sporadically from middle to upper part of the Rabbitkettle Formation.

Material: 8 specimens

Illustrated Material: GSC50702

## Genus Drepanoistodus Lindström, 1971
emend. Van Wamel, 1974

Type species: Oistodus forceps Lindström, 1955

Discussion: The following redefinition of the genus Drepanoistodus Lindström, was proposed by Van Wamel, 1974:

"Drepanoistodus is a multielement genus with drepanodiform, acodiform, suberectiform, scandodiform and oistodiform elements. Except for the oistodiform elements, all element types may carry costae, thus forming paltodiform (after the form genus Paltodus Pander, 1856) elements. The oistodiform elements have an anteroposteriorly extended base, which may open to one side. Cusp and base of the oistodiform elements meet at a sharp angle and in most specimens there is no inverted base anteriorly. Both white and hyaline forms occur."

There are at least three problems with Van Wamel's reconstruction and amendment of this genus:

(1) that the acodiform, scandodiform and paltodiform elements of many species included here are very similar.

(2) that often, as is also evident to a lesser degree with Lindström's (1971) reconstruction, complete apparatuses are not present in the collections. Thus, by accepting Van Wamel's reconstructions, an increased uncertainty is evident as a multielement species results in being recognized on the basis of one of the five possible constituents.

(3) Van Wamel's study was based on local collections, whereas Lindström's study was based on a much larger collection, from a broader geographic area.

Van Wamel's reconstruction probably is most pertinent to *Drepanoistodus conulatus* (Lindström).

### Drepanoistodus basiovalis (Sergeeva)

(Pl. 3, figs. 5, 6; Pl. 6, fig. 8; Pl. 13, figs. 4, 9, 10, 12-16)

Drepanodus planus Lindström, 1955, p. 565, Pl. 2, figs. 35-37, text-fig. 4a; Viira, 1967, fig. 1 (17); non Schopf, 1966, p. 54, Pl. 5, fig. 21.

Drepanodus suberectus (Branson and Mehl), Lindström, 1955, p. 568, Pl. 2, figs. 21, 22; Fåhraeus, 1966, p. 23, Pl. 2, fig. 10, text-fig. 2D; Viira, 1967, fig. 1 (24); Bradshaw, 1969, p. 1150, Pl. 135, fig. 7; Uyeno and Barnes, 1970, p. 107, Pl. 21, fig. 15.

Oistodus basiovalis Sergeeva, 1963, p. 96, Pl. 7, figs. 6, 7; Viira, 1967, fig. 1 (10).

Drepanodus homocurvatus Lindström. Fåhraeus, 1966, pp. 21-22, Pl. 2, fig. 11a,b, text-fig. 2E; Bradshaw, 1969, p. 1150, Pl. 135, fig. 8; Uyeno and Barnes, 1970, p. 107, Pl. 21, fig. 9.

Oistodus inclinatus Branson and Mehl. ?Fåhraeus, 1966, p. 24, Pl. 3, fig. 2, text-fig. 2g; ?Bradshaw, 1969, p. 1156, Pl. 133, figs. 11-13; Uyeno and Barnes, 1970, p. 109, Pl. 21, fig. 8.

Oistodus sp. Bradshaw, 1969, p. 1159, Pl. 135, figs. 10, 11.

Drepanoistodus basiovalis (Sergeeva), Lindström, 1971, pp. 43-44, figs. 6, 8; Barnes and Poplawski, 1973, p. 775, Pl. 4, figs. 3, 4, 7; Barnes, in Workum et al., 1976, pp. 171, 173, Pl. 4, figs. 1, 2; Barnes, 1977, p. 101, Pl. 1, figs. 4-6.

Remarks: Barnes and Poplawski (1973) have reviewed the current concept of D. basiovalis. The distinguishing feature (?) of the oistodiform element, O. basiovalis, is the best means for species identification [a relatively short cusp compared to the length of the base and a smoothly curved basal margin that meets the anterior margin at about $90^{\circ}$ (Barnes and Poplawski (op. cit.))]. Drepanodiform elements are supposed to be less recurved. I have been unable to identify the drepanodiform elements with complete confidence for this species. Elements of this species recognized from the Road River Formation are identified as D. basiovalis sensu lato.

Occurrence: High in the Broken Skull Formation, basal Sunblood Formation at Section H and Road River Formation at Section K (K2375:724), Locality 5 and Locality 2.

Material: Oistodiform elements 13, suberectiform elements 11, homocurvatiform elements 41, planus form elements 21 (over 50 additional elements).

Illustrated Material: GSC50203, GSC50884, GSC50911, GSC50322, GSC50341, GSC50342, GSC50343, GSC50344, GSC50345, GSC50346, GSC50347

Drepanoistodus conulatus (Lindström), emend. Van Wamel s.l.

(Pl. 9, figs. 9, 10, 14)

aff. Drepanodus conulatus Lindström, 1955, p. 561, Pl. 2, fig. 34, Pl. 4, fig. 34.

Scandodus furnishi Lindström, 1955, p. 592, Pl. 5, fig. 3.

Scandodus furnishi Lindström, emend. Lindström, 1971, p. 39.

aff. Drepanodus cyranoicus Lindström, 1955, p. 561, Pl. 5, fig. 8.

Drepanoistodus conulatus (Lindström), Van Wamel, 1974, pp. 63, 64, Pl. 3, figs. 1-4.

Discussion: The specimens assigned here conform broadly to Lindström's (1971) reinterpretation of Scandodus furnishi. The oral edges of the basal margin of the drepanodiform elements are strongly keeled and the inner face of the keeled cusp is slightly costate. Also, the outer cusp face may be very faintly carinate distally. Van Wamel (1974) considered the apparatus of Scandodus furnishi Lindström to belong to Drepanoistodus emend. Van Wamel, 1974; and gave the apparatus the new name Drepanoistodus conulatus (Lindström). His reconstruction is accepted here because both Scandodus furnishi s.f. and Drepanodus conulatus s.f. appear to conform to an oistodiform and drepanodiform morphology as modified by Van Wamel. Van Wamel noted (p. 64) that S. furnishi is more akin to the oistodiform (i.e. erect scandodiform) elements. Another element (Pl. 9, fig. 10) shows a morphology that is intermediate between S. furnishi and

D. conulatus.

Occurrence: Sporadic elements of this taxon are present throughout the lower, middle and upper parts of the Broken Skull Formation.

Material: Suberectiform elements 8, furnishiform elements 7, drepanodiform elements 15, amongst others.

Illustrated Material: GSC50054, GSC50264, GSC50265

## Drepanoistodus forceps (Lindström) s.l.

(Pl. 2, figs. 12, 13, 18; Pl. 7, figs. 7, 11, 13; Pl. 11, figs. 12, 13;
Pl. 13, figs. 5, 6, 19 (?))

Oistodus forceps Lindström, 1955 , p. 574, Pl. 4, figs. 9-13, text-fig. 3M.

Drepanoistodus forceps (Lindström), Lindström, 1971, p. 42, figs. 5, 8; Serpagli, 1974, p. 46, Pl. 10, figs. 8a-12c; Pl. 21, figs. 9-14 (includes synonymy); Van Wamel, 1974, p. 64, Pl. 2, figs. 14-22 (in part only).

Remarks: Both Van Wamel (1974) and Serpagli (1974) noted the confusion between D. forceps, D. basiovalis and D. suberectus. Van Wamel (1974) selected a more drastic approach, that of including all the three taxa into one, namely D. forceps. Serpagli (1974) tried to select various constituents of D. forceps mainly on geographic and age criteria so that most elements of D. forceps were either from the North Atlantic province or from other regions that contained a North Atlantic fauna. Moreover, the age was restricted to the Lower Ordovician (in this, Serpagli has followed Lindström, 1971). The oistodiform element of D. forceps is most distinct (elongated posteriorly so that a sharp postero-basal angle is present). The drepanodiform elements are difficult to distinguish from those of other Drepanoistodus species. Their identification is based on association and age criteria.

Occurrence: This species is well represented in the Road River and the Broken Skull Formations.

Material: Oistodiform elements 28, drepanodiform elements over 100.

Illustrated Material: GSC50972, GSC50026, GSC50024, GSC50923, GSC50920, GSC50921, GSC50305, GSC50306, GSC50339, GSC50340, GSC50335

### *Drepanoistodus suberectus* (Branson and Mehl)

(Pl. 26, figs. 25-27)

*Oistodus suberectus* Branson and Mehl, 1933, p. 111, Pl. 9, fig. 7.

*Drepanodus suberectus* (Branson and Mehl), Bergström and Sweet, 1966, pp. 330-333, Pl. 35, figs. 22-27; Weyant, 1968, p. 47, Pl. 2, figs. 11, 12 (drepanodiform element); Ethington and Schumacher, 1969, pp. 461, 462 (drepanodiform element); Globensky and Jauffred, 1971, p. 55, Pl. 4, figs. 3-6; Moskalenko, 1972, p. 52, fig. 6; Moskalenko, 1973, pp. 33, 34, Pl. 1, fig. 4 (drepanodiform element).

*Drepanodus homocurvatus* Lindström, Weyant, 1968, pp. 46, 47, Pl. 3, fig. 13 (drepanodiform element); Ethington and Schumacher, 1969, p. 461 (drepanodiform element); Moskalenko, 1973, pp. 32, 33, Pl. 1, fig. 3 (drepanodiform element).

*Oistodus inclinatus* Branson and Mehl, Ethington and Schumacher, 1969, p. 467, Pl. 68, fig. 7 (oistodiform element); Weyant, 1968, p. 53, Pl. 2, fig. 8 (oistodiform element); Moskalenko, 1973, p. 36, Pl. 1, fig. 7 (oistodiform element).

*Drepanoistodus suberectus* (Branson and Mehl), Uyeno, 1974, p. 14, Pl. 1, figs. 5-9; Barnes, 1977, p. 106, Pl. 3, figs. 18-20 (additional synonymy).

*Remarks*: The collections at hand contain representatives of all of the form-species of *Drepanoistodus suberectus*, including: *Drepanodus suberectus*, *D. homocurvatus*, and *Oistodus inclinatus*. *Drepanoistodus suberectus* is represented throughout the Middle Ordovician of the southern Mackenzie Mountains. Bergström and Sweet

(1966) argued at length to retain this name for this Middle Ordovician taxon. Elements of D. forceps show some similarity to those of D. suberectus, and in some instances are difficult to separate.

Occurrence: The species is common throughout the Middle Ordovician collections from both the Selwyn Basin and the Mackenzie Platform.

Material: Oistodiform elements 14, homocurvatiform elements 68, suberectiform elements 19, plus several broken elements.

Illustrated Material: GSC50190, GSC50191, GSC50192

## *Drepanoistodus* ? spp.

(Pl. 18, figs. 16, 18, 20)

*Remarks:* Several hyaline cones of Whiterockian age probably have a drepanoistodid affinity and consists of drepanoidiform and oistodiform elements. These are grouped under *Drepanoistodus* ? spp. s.f.

It is possible that elements of *Drepanoistodus* ? spp. may have been individually illustrated and described under separate taxa by Mound (1965).

*Description:* The elements of this multielement species are characterized by a cusp that has its greatest width either at the middle or upper half of the unit and a base that possesses both anterior and posterior extensions. In the former respect, the elements resemble *Drepanodus simplex* Branson and Mehl. The latter feature is shown by *Drepanodus incurvus* (Pander), and *Falodus prodentatus* (Graves and Ellison), as identified by Mound (1965). An additional element includes a variant that has an eoligonodiniform? outline (herein the unit possesses an antero-lateral extension caused by the inward deflection of the anterior extension). All three elements tend to co-occur, are of the same size and are hyaline.

*Occurrence:* From the Whiterockian collections of the Sunblood Formation at Sections E and G.

Material: Oistodiform elements 8, drepanodiform elements 4, eoligonodiniform element ? 1.

Illustrated Material: GSC50423, GSC50424, GSC50716

## Genus Eoneoprioniodus Mound, 1965, emend. Barnes, 1977

Type species: Oistodus bilongatus Harris, 1962

Definition: "Herein, the generic diagnosis by Mound (1965a) is emended: predominantly hyaline conodonts with a skeletal apparatus following the prioniodont plan. The cordylodiform, zygognathiform and trichonodelliform elements have long slender cusps and sharp margins or costae that extend down into short laterally-compressed processes that are adenticulate to weakly denticulate. Oistodiform and dichognathiform elements have shorter, broader cusps that are more sharply reclined. The basal cavity is large and deep, conical in lateral view, ramiform elements commonly have lobate lateral basal margins." (Barnes, 1977)

Remarks: The extension of this multielemental diagnosis for Eoneoprioniodus Mound is timely, and accepted here. It is clear that the basic plan of this genus is similar to that of late Whiterockian components of the Hyaline Prioniodid Series (Sweet et al., 1971). Clearly Barnes (1977) had noted this (in identifying a denticulated form as 'Eoneoprioniodus' sp. Barnes). Herein, the fully denticulated elements are referred to as "Eoneoprioniodus." The non-denticulated forms are rather sparse in my collections [e.g. Eoneoprioniodus ? spp.].

Roundyaform element: This element possesses a tall, compressed central cusp, that is flanked by denticulated lateral processes, of subequal length, approximately at 90° to the cusp. However, the two processes are not necessarily in the same plane. The denticles are basally confluent and separated apically. They are quite sharply compressed. Similar elements were illustrated by Sweet et al. (1971, Pl. 1, fig. 28) and Mound (1965, Pl. 1, fig. 27).

Cladognathiform element: This element includes forms that are less symmetrical than those included in the roundyaform elements. The cusp is usually less compressed compared to the roundyaform elements, and is well costate, both laterally and posteriorly. The two lateral processes are curved backwards and/or downwards. There is some evidence of a posterior process [if this is true, then some of the elements included here may belong to tetraprioniodiform elements (see Sweet et al., 1971, Pl. 1, fig. 30)].

Cordylodiform element: Herein are included elements that show forms that are more like cyrtoniodiform-eoligonodiniform type in morphology. These elements possess a strong, robust, compressed and well costate cusp, along with the three processes. The posterior process is nearly perpendicular to the cusp and carries up to 5 denticles that are subequal and discretely arranged, usually leaning away from the cusp. The anterior process is a downward extension of the anterior margin, and usually carries up to three poorly developed, discrete denticles. This process is rather short. The lateral non-denticulated process is usually an extension of the lateral costae. In most specimens, it was found to be broken.

Remarks: Elements of "Eoneoprioniodus" n. sp. A and "Phragmodus" n. sp. A usually co-occur in several late Whiterockian collections from the study area. These two multielement species include forms usually referred to as 'Hyaline Prioniodids'. They are important both in a stratigraphic and evolutionary sense.

Occurrence: Late Whiterockian collections of the Sunblood Formation.

Material: Prioniodiform elements 17, roundyaform elements 21, cladognathiform elements 17, cordylodiform elements 16.

Illustrated Material: GSC50439, GSC50440, GSC50441, GSC50442, GSC50443, GSC50444

## Eoneoprioniodus ? spp.

(Pl. 17, figs. 18, 19)

Remarks: After some indecision, I have decided to include the few broken elements of hyaline aspect that occur sporadically in the lower Whiterockian part of the Sunblood Formation into this genus. The elements, by themselves, could best be described as robust, with erect to suberect cusps that are highly costate; in most instances, the costae extend downwards for a short distance as processes. There is, however, no trace of denticles on any of the processes. Sharp costae develop posteriorly, anteriorly and laterally so that a quadrilateral type of cross section is present for the cusp. Generic diagnosis of this genus, as emended by Barnes (1977), includes a long slender cusp. It is only in the presence of a robust cusp that these forms are different from those included in this genus.

Occurrence: Lower Whiterockian collections from the lower part of the Sunblood Formation and Broken Skull Formation.

Material: 17 specimens

Illustrated Material: GSC50399, GSC50400

### Genus *Eoplacognathus* Hamar, 1966

*Type species:* *Ambalodus lindstroemi* Hamar

*Remarks:* *Eoplacognathus* includes ambalodiform and polyplacognathiform elements in an apparatus reminiscent of *Polyplacognathus* (Bergström, 1971).

### *Eoplacognathus planus* (Sergeeva)

(Pl. 4, fig. 9; Pl. 5, figs. 2, 4)

?*Ambalodus* n. sp. 2 Lindström, 1960, fig. 4 (5).

*Ambalodus planus* Sergeeva, 1963, p. 105, Pl. 8, figs. 11-14, text-fig. 10a,b; Sergeeva, 1966, p. 11, fig. 8.

*Lenodus clarus* Sergeeva, 1963a, p. 138, figs. 1a-e.

*Ambalodus* sp. 1 Lindström. Viira, 1967, figs. 16a,b.

?*Eoplacognathus suecicus* Bergström. Barnes and Poplawski, 1973, p. 775, Pl. 2, figs. 2, 3.

*Amorphognathus variabilis* Sergeeva. Viira, 1974, Pl. 7, figs. 3, 4 (upper right).

*Amorphognathus* n. sp. 1 Viira, 1974, Pl. 7, fig. 1

*Remarks:* Elements of *E. planus* (Sergeeva), consisting of ambalodiform and polyplacognathiform elements, were first described by Sergeeva (1963) under two form species, *Ambalodus planus* and *Amorphognathus variabilis*. The collection at hand contains several elements of *A. planus*. However, only one polyplacognathiform element of the type conforming to *A. variabilis* was recovered.

This element (Pl. 5, fig. 2) is small and fragmentary. It contains four lobes, with a central row of denticles on each lobe, a diagnostic feature of this form. The ambalodiform element appears to show considerable variation in the size, width and sinuosity of the anterior process (compare Pl. 4, fig. 9 and Pl. 5, fig. 4). Viira (1972) pointed out the different shapes of the sinistral and dextral representatives of this species.

**Occurrence:** Road River Formation at Section K (K2375:724). This species has been reported from some North American localities although it is a common constituent of the Baltic region as noted from Lindström (1960), Sergeeva (1964) and Viira (1974), amongst others.

**Material:** Ambalodiform elements 10, amorphognathiform element 1.

**Illustrated Material:** GSC50193, GSC50197, GSC50732

## Eoplacognathus n. sp. A ?

(Pl. 5, figs. 1, 5, 7)

Description: The ambalodiform element of this taxon is represented by a robust dextral ambalodiform element that consists of a short posterior process and long, probably subequal anterior and lateral processes. The anterior process is gently curved, narrowing distally and bears several very poorly developed 'denticles'. The posterior process terminates abruptly behind the cusp, and may be broken off. However, more probably the process is indeed short. The lateral process also tapers distally and carries a similar mode of denticulation to that of the anterior process. The basal cavities under the three processes are narrow and slitlike. Amorphognathiform elements are generally broken such that only three processes are seen. Moreover, the inability to distinguish between anterior and posterior processes makes a detailed description almost impossible. I have therefore only illustrated the specimens that I believe are parts of the Eoplacognathus n. sp. A ? apparatus.

Remarks: The inclusion of amorphognathiform elements is based on the criteria of co-occurrence and the supposition that amorphognathiform elements invariably are parts of an Eoplacognathus apparatus.

The ambalodiform element of this species is probably close to the ambalodiform element illustrated by

Lindström (1960) as Ambalodus n. sp. 5.

Occurrence: Road River Formation at Section K (K2375:724).

Material: Ambalodiform element 1, amorphognathiform elements 12.

Illustrated

Material: GSC50194, GSC50198, GSC50897

### Genus Erismodus Branson and Mehl

Type species: Erismodus typus Branson and Mehl, 1933

Remarks: As was noted earlier under Curtognathus, Erismodus is regarded here as a multielement genus, that contains elements previously included under Ptiloconus and Microcoelodus. Erismodiform elements include symmetrical forms with at least two processes that project downwards from the apical cusp. Additional processes may be present, one of which is usually the extention of the antero-lateral margin.

Microcoelodiform elements are similar, but consist of asymmetrical forms and also include the ptiloconiform element which has the lateral process much reduced and somewhat twisted.

### Erismodus spp.

(Pl. 25, figs. 2-4, 12, 13)

Erismodus symmetricus Branson and Mehl, 1933, p. 104, Pl. 10, fig. 10; Andrews, 1967, pp. 892, 893, Pl. 112, figs. 4, 5, 13, 16, 21, Pl. 113, fig. 7, Pl. 114, figs. 4, 18, 24; Webers, 1966, p. 63, Pl. 4, fig. 7.

Erismodus typus Branson and Mehl, 1933, p. 25, Pl. 1, figs. 9, 11, 12; McLaughlin, 1941, in Branson, 1944, p. 67, Pl. 9, figs. 29, 30; Sweet, 1955, p. 234, Pl. 27, fig. 5, Pl. 29, figs. 7, 8; Hass, 1962, p. 53, fig. 32-2; Andrews, 1967, pp. 891, 892, Pl. 112, figs. 9, 10, 11, 18; Pl. 114, fig. 21.

Erismodus asymmetricus (Branson and Mehl) Andrews, 1967, pp. 893, 894, Pl. 112, figs. 1, 3, 6, 7, 14, 17; Pl. 113, fig. 1; Pl. 114, figs. 7, 9, 13 (see for additional synonymy till 1967); Atkinson, 1971, Pl. 4, fig. 12.

Erismodus gracilis (Branson and Mehl) Andrews, 1967, p. 894, Pl. 112, fig. 19 (additional synonymy till 1967).

Occurrence: Sporadically through the Chazy and Lower Blackriveran strata of the Sunblood and Esbataottine formations, Mackenzie Platform.

Material: Erismodiform elements 12, microcoelodiform elements 14, ptiloconodiform elements 8, in addition to fragmentary elements exceeding 70.

Illustrated Material: GSC50514, GSC50133, GSC50515, GSC50132, GSC50522

## '*Erismodus*' n. sp. 1 s.f.

(Pl. 20, figs. 7, 8)

Diagnosis: An erismodid element having three denticulated processes in a prioniodid fashion, a triangular aboral outline and a relatively deep basal cavity.

Description: The cusp is broad, moderately robust, keeled anteriorly, poorly costate posteriorly and laterally. It has an elliptical to subrounded cross section, and thickens rather abruptly towards the base. Three processes are present. The three processes, anterior, posterior and lateral, are of subequal length and carry about equal numbers (4 to 5) of confluent subequal denticles. The posterior and lateral processes are relatively straight whereas the anterior process is curved laterally. Usually two of the three processes are aligned in one plane, while the third is disposed approximately at 90° to this plane.

In some elements, the posterior process is offset to one side and imparts an asymmetry to the unit. However, the relationship between the three processes noted earlier remains almost unchanged.

The elements are in some ways reminiscent of *Erismodus* ? *horridus*, although in the latter taxon the denticles are quite different (tall and quite discrete), while there appears to be a greater asymmetry.

Remarks: This element is found in collections that also include elements of "*Phragmodus*" n. sp. A and "*Eoneoprioniodus*" n. sp. A.

Occurrence: Late Whiterockian collections from the Sunblood Formation.

Material: 12 specimens

Illustrated Material: GSC50114, GSC50113

### "Erismodus" sp. A

(Pl. 24, figs. 11, 13, 14, 15)

Remarks: Elements of this species are non-hyaline. Hence the noted designation.

Description: The trichonodelliform element bears a thick but relatively short cusp flanked by one to three apically separated but basally confluent compressed denticles leaning away from the median cusp. The cordylodiform element has a similar cusp, and bears at least one antero-lateral denticle and one to possibly three posterior denticles. The zygognathiform element usually bears up to three compressed denticles on the sides. The area of the basal opening varies. In some forms it is only present under the cusp and in others it spreads laterally under the denticles; and is invariably wide and deep.

Occurrence: Blackriveran collection from Esbataottine Formation at Sections A and P.

Material: Trichonodelliform elements 3, zygognathiform elements 7, cordylodiform elements 6.

Illustrated Material: GSC50506, GSC50507, GSC50508, GSC50509

### 'Erisмodus' ? spp. s.f.

(Pl. 25, figs. 15, 16)

Remarks: A few robust, stout-looking, erismodiform elements are included here. One of these units (Pl. 25, fig. 16) lacks a distinctive cusp and has three thick, almost platformlike, downwardly directed processes. The apical region (cusp?) is thick and robustly rounded in cross section, while the processes appear to become narrower downward. There is a shallow groove under the processes and a small basal pit under the apex. The other element included here (Pl. 25, fig. 15) shows the same type of general robustness, but contains a distinctive erect and straight cusp having a lanceolate cross section that is pointed apically. From an area near the base of the cusp, two processes extend downward in near continuity with the cusp sides. Additional processes are directed posteriorly and anteriorly. These are much shorter and may be broken. However, they are oblique to the cusp. The underside of the unit is shallowly excavated.

Occurrence: A few collections from the Sunblood Formation.

Material: 7 specimens

Illustrated Material: GSC50523, GSC50134

## Genus Evencodus Moskalenko, 1970

Type species: Evencodus sibiricus Moskalenko, 1970

Definition: Simple conical bilaterally symmetrical to somewhat asymmetrical conodonts with rounded anterior and posterior edges and lateral sides. Basal edge is uneven with lateral or anterior projection of the erismodid type; often completely ribbed. Basal surface with a depression or flat. (Approximate translation of the Russian text.)

Remarks: In a later study, Moskalenko (1972) distinguished E. sibiricus as a multielemental taxon. This was based on the criteria of co-occurrence, uniformity of shape and size, and to a certain extent microsculpture. The few specimens that are present in my collection are similar to but not conspecific with Evencodus sibiricus Moskalenko.

### Evencodus sp. aff. E. sibiricus Moskalenko

(Pl. 20, figs. 17, 20, 21)

aff. Evencodus sibiricus Moskalenko, 1970, pp. 44-45, Pl. 3, figs. 1a,b.

aff. Evencodus trilobatus Moskalenko, 1970, pp. 45, 46, Pl. 2, fig. 3.

aff. Evencodus furcatus Moskalenko, 1970, pp. 42, 43, Pl. 2, figs. 1a,b.

Remarks: Moskalenko (1972) united the three form species of Evencodus, E. sibiricus, E. trilobatus and E. furcatus, into a multielement species, E. sibiricus. This is accepted here. Although material at hand is limited to a few specimens only, it is clear that the reasons stressed by Moskalenko, noted earlier, are equally applicable to this collection.

Of the illustrated specimens, Pl. 20, figs. 17 and 20 are similar to the form species E. furcatus and E. sibiricus, while Pl. 20, fig. 21 is similar to the form species E. sibiricus.

Occurrence: Lower part of the Sunblood Formation from sample S290.

Material: 12 specimens

Illustrated Material: GSC50396, GSC50397, GSC50398

## Genus Furnishina Müller, 1959

Type species: Furnishina furnishi Müller, 1959

Remarks: This genus was originally defined by Müller (1959, p. 451). Subsequent histologic studies of the crown and basal filling by Müller and Nogami (1971) suggest that it should be included within the paraconodonts, and thus is not an euconodont *sensu* Bengston (1976).

### Furnishina ? sp. s.f.

(Pl. 1, fig. 6)

Remarks: The specimen is fragmentary and the basal portion may be missing. It is certainly broken. The expansion of the base just above the position of the breakage, the presence of a low lateral carina, the subrounded cross section of the cusp, and the triangular to subrounded basal opening, show some similarity to *F. primitiva* Müller.

Occurrence: Low in the Rabbitkettle Formation.

Material: 2 specimens

Illustrated Material: GSC50854

## Genus *Gothodus* Lindström, 1955

*Type species*: *Gothodus costulatus* Lindström, 1955

*Remarks*: There is some confusion as to the status of this form genus and its relationship to *Acodus* Pander and *Prioniodus* Pander. Serpagli (1974) considered it to be a junior synonym of *Prioniodus*. The problem is unresolved because Van Wamel (1974) described a new form species of *Gothodus*, *G. microdentatus*. The same taxon is also present in my collection.

Klapper *et al*. (1977) have placed *G. microdentatus* in synonymy with *Oepikodus communis* (Ethington and Clark).

### *Gothodus microdentatus* Van Wamel s.f.

(Pl. 2, fig. 19)

*Gothodus microdentatus* Van Wamel, 1974, p. 69, Pl. 5, figs. 14a,b and 15a,b.

*Occurrence*: Road River Formation, Section K.

*Material*: 2 specimens

*Illustrated Material*: GSC50971

## Genus Hertzina Müller, 1959

Type species: Hertzina americana Müller, 1959

### Hertzina ? sp. s.f.

(Pl. 1, fig. 1)

Remarks: Only one fragmentary specimen containing a deep basal cavity and faint lateral carinae is assigned tentatively to this genus. Similar elements without the carinae have been included in Prooneotodus tenuis.

Bengston (1976) while discussing the species of Hertzina, H. ? bisulcata Müller, pointed out its variability which he termed as intraspecific. He preferred to retain the question mark, despite its removal by several workers (e.g. Clark and Miller, 1969; Landing, 1974). The element in question is in most aspects similar to Prooneotodus tenuis Müller, but it bears two fine lateral carinae. Moreover, under high magnification, the element also shows some evidence of 'growth lines' that appear to lie transverse to the cusp. In this respect, it is similar to Hertzina ? bisulcata Müller. Hence the designation H. ? sp. is adopted here. The species appears to be close to H. elongata Müller (Müller, 1959, Pl. 13, fig. 28), although the lateral carinae are not as prominently seen as in the latter form.

Occurrence: Occurs in Rabbitkettle Formation K525:160.

Material: 1 specimen

Illustrated Material: GSC50015

## Genus Histiodella Harris, 1962

Type species: Bryantodina sinuosa Graves and Ellison, 1941

Remarks: Histiodella has a flat, blade-like plate with indistinct, incipient to well developed denticles on its upper edge. The whole unit rests upon a low, elongated base with narrow cavity. The surface is usually smooth. On most forms a low, longitudinal lateral ridge marks the junction of the flat plate and base.

Sweet et al. (1971) noted that species of Histiodella evolved from forms with a sharp, undenticulated upper edge and a triangular outline (e.g. H. altifrons) to forms with developed denticulation and a more elongate shape (e.g. H. sinuosa). Fully denticulated forms should probably be included in H. serrata (Barnes and Poplawski, 1973; and Landing, 1976).

My interpretation of H. sinuosa and H. serrata differs from those of Barnes and Poplawski (1973) and Landing (1976) (see under Histiodella sp. A).

Histiodella sinuosa (Graves and Ellison) s.f.

(Pl. 18, figs. 1, 2)

Bryantodina sinuosa Graves and Ellison, 1941, pp. 9, 10, Pl. 2, fig. 13.

Histiodella sinuosa (Graves and Ellison), Lindström, 1964, pp. 157, 177, fig. 54C; Mound, 1965, p. 23, Pl. 3, figs. 5, 8, 9; Bradshaw, 1969, p. 1151, Pl. 137, fig. 24.

Remarks: See below, under Histiodella sp. A.

Occurrence: From a Sunblood Formation collection near Caribou Range (S290).

Material: 12 specimens

Illustrated Material: GSC50410, GSC50411

## *Histiodella* sp. A Sweet *et al*. s.f.

(Pl. 18, fig. 4)

*Histiodella* sp. A Sweet *et al*., 1971, Pl. 18, fig. 4.

*Histiodella serrata* Harris, Landing, 1976, p. 633, Pl. 1, fig. 20.

*Histiodella sinuosa* (Graves and Ellison), Barnes and Poplawski, 1973, pp. 776-777, Pl. 1, figs. 17, 18.

*Spathognathodus* n. sp. Lindström, 1960, text-fig. 5(3); Fåhraeus, 1970, fig. 3I.

*Spathognathodus* sp. Viira, 1967, text-fig. 4(8); Uyeno and Barnes, 1970, p. 117, Pl. 24, figs. 12, 13.

*Remarks*: Elements of *Histiodella* sp. A Sweet *et al*., 1971, have been included in *H*. *serrata* and *H*. *sinuosa* by Landing (1976) and Barnes and Poplawski (1973), respectively. I believe, however, that this present species is quite different from either of those, as originally defined. A complete description is available in Uyeno and Barnes (1970). It can be seen that in profile this species is almost rectangular, whereas both *H*. *serrata* and *H*. *sinuosa* have a triangular profile. Possibly, the trend amongst the histiodellids includes, along with increasing denticulation, a flattening of the profile from triangular to elongated to almost rectangular.

*Occurrence*: From collection B310:94, Sunblood Formation.

*Material*: 1 specimen

Illustrated

Material: GSC50414

## Genus Juanognathus Serpagli, 1974

Type species: Juanognathus variabilis Serpagli

Remarks: Landing (1976) pointed out the protopanderodid affinities of this genus but suggested that the term be retained for the time being. However, I feel that the elements of this genus, especially of Juanognathus variabilis, are closer to paltodids sensu Paltodus variabilis Furnish and probably represent a separate lineage from protopanderodids similar to P. gradatus Serpagli.

## Juanognathus jaanussoni Serpagli

(Pl. 17, figs. 6-8)

Acodus n. sp. Ethington and Clark, 1965, p. 187, Pl. 2, figs. 3, 4.

Conodont undet. Uyeno and Barnes, 1970, pp. 118, 119, Pl. 22, figs. 16, 17.

?Paltodus n. sp. Lee, 1970, p. 331, Pl. 8, figs. 2a,b.

Juanognathus jaanussoni Serpagli, 1974, pp. 50, 51, Pl. 11, figs. 8a-12c, Pl. 23, figs. 1a-5b, text-fig. 9.

Remarks: The specimens studied appear to be identical to those figured by Serpagli (1974). The specimens recovered from the San Juan Limestone (Serpagli, 1974) occurred in strata higher than those bearing J. variabilis; however, the opposite appears to be the case here. In the study area, J. jaanussoni occurs below as well as together with J. variabilis.

Occurrence: From the middle and upper part of the Broken Skull Formation.

Material: 70 specimens

Illustrated Material: GSC50386, GSC50387, GSC50388

## Juanognathus variabilis Serpagli

(Pl. 17, figs. 9-14)

?Acontiodus sp. B Igo and Koike, 1967, p. 17, Pl. 2, fig. 15, text-fig. 4.

?Scolopodus sp. A Igo and Koike, 1967, p. 26, Pl. 2, figs. 7a,b, text-fig. 51.

?Paltodus sp. D Ethington and Clark, 1971, pp. 67, 77, Pl. 2, fig. 7.

Juanognathus variabilis Serpagli, 1974, pp. 49, 50, Pl. 11, figs. 1a-7c, Pl. 22, figs. 6-17, text-fig. 8; Landing, 1976, p. 634, Pl. 2, figs. 15-17, 19-23.

Remarks: The specimens of this species conform exactly to Serpagli's (1974) description, and they exhibit the complete range of variation shown by him. Interestingly, J. variabilis has the same stratigraphic range as Oepikodus evae in the San Juan Limestone, while in the upper Broken Skull Formation the range of J. variabilis coincides with that of Oepikodus communis.

Occurrence: Upper part of the Broken Skull Formation and basal Sunblood Formation at Section H.

Material: 32 specimens

Illustrated Material: GSC50389, GSC50390, GSC50391, GSC50392, GSC50393, GSC50733

### Genus Keislognathus Rhodes, 1955

Type species: Keislognathus gracilis Rhodes, 1955

Remarks: This genus, as presently interpreted, is a component of the multielement genus Amorphognathus. However, the presence of keislognathiform elements without the accompanying amorphognathids or the absence of such elements from amorphognathids previously described from older Middle Ordovician rocks forces me to treat this genus as a form taxon. One keislognathiform element, occurring in the Whittaker Formation, probably belongs to Amorphognathus sp. A ? of this study.

Keislognathus sp. aff. K. pyramidalis (Sweet and Bergström) s.f.

(Pl. 3, fig. 10)

aff. Roundya pyramidalis Sweet and Bergström, 1962, pp. 1243-1244, Pl. 170, figs. 7, 8, 9.

Remarks: The specimen differs from that described and illustrated by Sweet and Bergström in lacking or having poorly developed denticles on the edges of the lateral processes as well as the posterior process. The cusp is slender, erect, shows a broadly rounded anterior face between prominent lateral costae. The posterior process is erect, has a rough edge, and is less strongly keeled than the Pratt Ferry specimens of Sweet and Bergström. The lateral processes are about as equally keeled as the Pratt Ferry specimens.

The present form could be ancestral to K. pyramidalis.

Occurrence: From the Road River Formation at Section K (K2145:654).

Material: 1 specimen

Illustrated Material: GSC50885

## Genus *Leptochirognathus* Branson and Mehl, 1943

Type species: *Leptochirognathus quadratus* Branson and Mehl, 1943

Emended Diagnosis: Hyaline conodonts with a skeletal apparatus that follows a reduced prioniodont plan, with only the cordylodiform, zygognathiform and roundyaform elements being present. All elements are characterized by thin, sharp-edged denticles, palmate in shape, that are fused into a common base, the unit varying from symmetrical (roundyaform) through slightly asymmetrical (zygognathiform) to markedly asymmetrical (cordylodiform). Usually a thin, shallow basal opening underlies the denticles.

Remarks: Branson and Mehl (1943) defined this genus as consisting of "three to five or more compressed thin, sharp-edged denticles fused into a common base, bilaterally symmetrical to markedly asymmetrical." They also noted its fibrous structure, palmate shape and superficial resemblance to *Chirognathus*.

Since this original study, *Leptochirognathus* has not been described in any later works in the taxonomic sense, although sporadic references continued to appear in the literature. Moskalenko (1972) illustrated some specimens of *Leptochirognathus*, but did not demonstrate its multielemental nature. Based on the description and discussion of this genus, including the many described and illustrated species from the McLish Formation, it can be noted that it shows a Roundya-Cordylodus symmetry transition [Sweet and Bergström (1972) noted this].

The following appears to be the elemental breakdown from Branson and Mehl (1943, Pl. 63): Roundya element [figs. 11-16 (L. semiflorealis) and figs. 18-21, ?22 (L. tridactyla)]; oulodiform element ? [figs. 23-28 (L. quadrata)]; cordylodiform element [figs. 29-40 (includes L. prima, L. obesa and L. gracilis)]. Leptochirognathus therefore is regarded as a multielemental genus.

### Leptochirognathus quadratus Branson and Mehl, 1943

(Pl. 25, figs. 5, 6)

Leptochirognathus erecta Branson and Mehl, 1943, p. 377, Pl. 63, fig. 18.

Leptochirognathus gracilis Branson and Mehl, 1943, p. 377, Pl. 63, figs. 39, 40.

Leptochirognathus obesa Branson and Mehl, 1943, p. 377, 378, Pl. 63, figs. 36-38.

Leptochirognathus prima Branson and Mehl, 1943, p. 378, Pl. 63, figs. 29-35.

Leptochirognathus semiflorealis Branson and Mehl, 1943, pp. 379, 380, Pl. 63, figs. 11-16.

Leptochirognathus tridactyla Branson and Mehl, 1943, p. 380, Pl. 63, figs. 17, 19-22.

Leptochirognathus quadrata Branson and Mehl, 1943, pp. 378, 379, Pl. 63, figs. 23-28.

Remarks: These elements have been individually described by Branson and Mehl (1943). My collections include representatives of all three types, namely 'roundya', 'cordylodus' and 'oulodus'; however only the 'roundya' and 'cordylodus' types are illustrated.

Occurrence: All specimens of Leptochirognathus come from one collection, taken from about 100 meters below the base of the Esbataottine Formation at Section A.

Material: Roundyaform elements 32, cordylodiform elements 18, oulodiform elements 21.

Illustrated

Material: GSC50516, GSC50517

## Leptochirognathus n. sp. A

(Pl. 18, figs. 6, 7, 9)

Diagnosis: A multielemental taxon of leptochirognathid morphology showing a symmetry transition of the 'roundya-cordylodus' type. All elements are characterized by the axial thickening of the denticles, and thickening along the ledge where the denticles and cusp join the base.

Remarks: The thickening is also seen in New Genus New Species D, although the two do not co-occur.

The placement of this species in Leptochirognathus cannot be disputed because the elements not only reflect the morphology of this genus but also to a great extent show a close homology with elements of Leptochirognathus quadratus Branson and Mehl.

Description: The roundyaform elements consist of three compressed, thin, sharp-edged denticles that are basally confluent. The elements are slightly asymmetric, the asymmetry resulting from the fact that there is no centrally erect denticle; the median one is usually leaning towards one of the other denticles. The third denticle normally leans only slightly away from the other two denticles. The basal opening is present under the three denticles, and is pinched towards the two ends. The cavity is not deep but probably deeper than that noted for L. quadratus.

The oulodiform element shows a greater asymmetry than the roundyaform element, but otherwise is similar. The cordylodiform element also possesses three denticles. Towards one extreme, the denticle is almost upright and part of the basal outline opens laterally. The denticle on the other extreme usually extends parallel to the base in a similar manner to that seen in *L. gracilis* s.f. The middle denticle is either leaning towards the extended one or is upright. In the latter case it is usually very short. The basal cavity is shallow.

*Remarks*: This species may be ancestral to *L. quadratus*.

*Occurrence*: Elements of this species are present in several Whiterockian collections from the Sunblood Formation. The species appears to be restricted to the lower part of the range of *Multioistodus subdentatus*.

*Material*: Roundya elements 19, oulodiform elements 14, cordylodiform elements 24.

*Illustrated Material*: GSC50415, GSC50095, GSC50416

## Genus Multioistodus Cullison, 1938

Type species: M. subdentatus Cullison, 1938

Remarks: See under M. subdentatus for discussion on the genus.

### Multioistodus subdentatus Cullison

(Pl. 18, fig. 17(?); Pl. 19, figs. 1-12)

Neomultioistodus compressus Harris and Harris, err. cit. pro Multioistodus (Neomultioistodus) compressus Harris and Harris, 1965, p. 43, Pl. 1, figs. 7a-c; Mound, 1965, p. 24, Pl. 3, figs. 12, 13 (for additional synonymy to 1965).

Multioistodus n. sp. Lindström, 1964, p. 82, fig. 26, F-1.

Multioistodus lateralis Cullison, Mound, 1965, pp. 24, 25, Pl. 3, figs. 14-16 (for additional synonymy to 1965).

Multioistodus subdentatus Cullison, Mound, 1965, p. 25, Pl. 3, figs. 17-18, 20, 25 (for additional synonymy to 1965).

Multioistodus tridens Mound, 1965, p. 26, Pl. 3, figs. 19, 24, 26.

Multioistodus compressus (Harris and Harris), emend. Bradshaw, 1969, p. 1153, Pl. 133, figs. 1-10; Pl. 136, figs. 2-4, 7-9.

Multioistodus compressus Harris and Harris. Sweet et al., 1971, Pl. 1, figs. 29, 36, 40.

Remarks: Bradshaw (1969) incorporated four form species of Multioistodus, namely M. compressus (Harris and Harris), M. lateralis Mound, M. subdentatus sensu Mound, 1965, and M. tridens Mound into a single multielement taxon, M. compressus. McHargue (1974) suggested that M. subdentatus extends to the base of the Whiterock, thereby throwing some doubt on the suggestions of Sweet *et al*. (1971) and Bradshaw (1969) that *M. subdentatus sensu* Cullison and *M. subdentatus sensu* Mound were two separate taxa. I do not believe that the two taxa noted above are different. Therefore, while accepting Bradshaw's reconstruction of *M. compressus*, priority would demand the apparatus to be included under *M. subdentatus*. McHargue (1974), after a study of several thousand specimens, suggested that the genus *Multioistodus* consists of several multielement species, two of which, namely *M. compressus* and *M. subdentatus*, were included in *M. compressus* by Bradshaw. In addition he noted the presence of three more species, namely *M. cryptodens* (Mound) and two others that include *Pteracontiodus aquilatus* Harris and Harris, and *Acodus auritus* Harris and Harris in one species and *Tricladiodus clypeus* Mound in the other species. McHargue (op. cit.) reaffirmed the presence of a 'roundya-cordylodus' type of symmetry (Lindström, 1966) for all these species. McHargue, however, did not publish his findings and I have no access to his thesis. At present, with the limited collections at hand, my approach has been to unite the various form species of *Multioistodus* into one taxon, *M. subdentatus*, as established by Bradshaw (1969). It is possible that elements of *Multioistodus subdentatus*, as presently interpreted, may belong to more than one species.

The apparatus of Multioistodus subdentatus Cullison best displays the basic features of the 'roundya-cordylodus' series of Lindström (1964). All elements show a considerable amount of intraelemental variation. The roundyaform and tetraprioniodiniform elements can be distinguished on the basis of the curvature of the anterior margin, which in the case of the tetraprioniodiniform element, points towards the anterior. These elements could probably be referred to as the trichonodelliform elements.

The cordylodiform element is the subdentiform element. It is distinguished by the absence of lateral costae or flanges, in addition to the presence of a denticulate posterior process. The variation includes forms that possess an anterior denticle directed laterally.

The cladognathiform element is highly variable. It includes elements included by Bradshaw (1969) in the cladognathiform type as well as variants that have a pteracontiodid plan, namely a tall central cusp, bordered by lateral denticles on either side. These denticles are shaped like the main cusp and are not lobate as seen in Pteracontiodus Harris.

Occurrence: Several collections from the Whiterockian part of the Sunblood Formation. A few have been questionably identified from the Late Whiterockian.

Material: Cordylodiform elements 25, trichonodelliform elements 34, zygognathiform elements 62 (several additional incomplete specimens are also there).

Illustrated Material: GSC50424, GSC50425, GSC50092, GSC50426, GSC50427, GSC50428, GSC50429, GSC50432, GSC50433, GSC50434, GSC50435, GSC50100

## *Multioistodus* spp.

(Pl. 14, figs. 13-15, 17, 19)

Remarks: This group includes bidentate conodonts with variably placed subequal to unequal denticles, which, when compared to *M. subdentatus*, could qualify as subdentiform and cladognathiform elements. Also included is a tridentate?roundya element which has a 'pteracontiodid' outline, a tall central cusp flanked by two lateral lobate denticles. One subdentiform element has a well rounded, suberect anterior denticle, and a sharply recurved posterior one, the basal end of which is almost fused into the anterior denticle. Another element included here has an inverted funnel-shaped cusp and denticles. The cusp is inclined at an angle of about 45° to the base, near the apex, and there are basal extensions both posteriorly and anteriorly (oppositely directed). The basal outline is subrounded, but the depth of the cavity cannot be determined.

The cladognathiform element includes two asymmetrically arranged denticles; the larger posterior denticle is inclined forward, while the smaller antero-lateral denticle is inclined backward. The other cladognathiform element is similar to *Multioistodus* sp. Bradshaw (1969), except for the absence of prominent ridges or carinae on each lateral face.

The roundyaform element, as noted earlier, has a 'pteracontiodid' outline that varies from a symmetric (roundya) to a less symmetric (cladognathiform?) morphology. In the less symmetric elements, the lateral denticles do not fall in the same plane as the central cusp. Transitional elements are present in the collections.

Occurrence: Sporadically through the Lower Sunblood Formation.

Material: Cladognathiform elements 3, subdentiform elements 16, roundyaform elements 32.

Illustrated Material: GSC50436, GSC50437, GSC50107, GSC50430, GSC50431, GSC50096

## Genus Oelandodus Van Wamel, 1974

Type species: Oistodus elongatus Lindström, 1955

Remarks: Van Wamel (1974) established a multielement genus Oelandodus that consisted of an oistodiform, elongatiform and triangulariform, which differed from Oistodus Pander by having an elongatiform element instead of a deltaform element.

Several elements from a single collection near the base of the Sunblood Formation (H0:0) probably could be included within this genus, especially with those of species O. costatus Van Wamel. Some of these elements (especially the elongatiform element, but to a lesser extent also the oistodiform and triangulariform elements) resemble the oistodiform and ramiform elements of New Genus A of Sweet, Ethington and Barnes, 1971 (described elsewhere in the thesis), but do not appear to be conspecific. I have, after some deliberation, decided to include these in the genus Oelandodus Van Wamel.

### Oelandodus sp.

(Pl. 14, figs. 16, 19; Pl. 15, figs. 11, 14)

aff. Oelandodus costatus Van Wamel, 1974, pp. 72-74, Pl. 7, figs. 5-7.

Remarks: This multielement taxon includes an oistodiform, an elongatiform and a triangulariform element. The oistodiform and the elongatiform elements are identical to the homologous elements of Oelandodus costatus Van Wamel, and nothing need be added to the description provided by Van Wamel. The distinctive feature is the rounded costa running along the basal sheath on each side. One triangulariform element is included with some hesitancy (Pl. 15, fig. 11). Herein, the lateral costae are more centrally placed than anteriorly, while the posterior oral margin forms a smooth curve with the base (see Van Wamel, 1974, p. 72). The anterior margin near the base is deflected forwards. The inclusion of this element is based on overall similarities with the triangulariform element of O. costatus, the costate apsect of the element, the size of the element and its occurrence with the oistodiform and elongatiform elements of this taxon in the same collection.

Occurrence: Near the base of the Sunblood Formation at Section H.

Material: Oistodiform elements 7, elongathiform elements 8, triangulariform elements 3.

Illustrated Material: GSC50355, GSC50356, GSC50367, GSC50368

### Genus Oepikodus Lindström, 1955, emend. Van Wamel, 1974

Type species: Oepikodus smithensis Lindström, 1955

Definition: "Oepikodus is a multielement genus which includes three types of conodont elements (prioniodiform, oepikodiform and falodiform). Prioniodiform elements have a stout suberect cusp and three processes, the posterior of which is always denticulated. The anterior and the outer lateral processes may or may not bear denticles. Oepikodiform elements have a proclined cusp, a mostly long anterior process (anticusp), two lateral processes and a long posterior process, which is the only one that bears denticles. Falodiform (oistodiform) elements are essentially simple conodont elements with a well developed base and a recurved cusp. No denticles are present on the anterior projection of the base" (Serpagli, 1974).

Remarks: In recent years, McTavish (1973), Bergström and Cooper (1973), Serpagli (1974) and Van Wamel (1974) have all felt the need to erect a new genus to accommodate Oepikodus evae (Lindström), which otherwise had been included with Prioniodus Pander. However, O. evae lacked belodiform elements, and its apparatus is considerably simpler than other prioniodids. Although Van Wamel (op. cit.) did establish this multielement genus, Serpagli deserves credit for attempting to distinguish between the three apparently related genera, Oepikodus Lindström, Prioniodus Pander and Baltoniodus Lindström. Serpagli also tried to distinguish between the two closely related species Oepikodus evae and Oepikodus communis (Ethington and Clark). The latter usually occurs in the Midcontinent region while the former is known from the North Atlantic Province or regions yielding North Atlantic taxa.

Serpagli introduced a new species, Oepikodus intermedius, which he believed occupied an intermediate position between O. evae below and O. communis above. Despite Serpagli's effort, the differences between O. communis and O. intermedius are not clear as homologous elements probably show some sort of intraelemental variations. I have therefore recognized only O. communis in my work. Most elements of O. evae also show a considerable amount of intraspecific variation (see both Serpagli, 1974, and Landing, 1976).

### *Oepikodus communis* (Ethington and Clark) s.l.

(Pl. 14, figs. 1-13)

*Gothodus communis* n. sp. Ethington and Clark, 1964, p. 690, Pl. 114, figs. 6, 14, text-fig. 2:F.

*Oepikodus equidentatus* n. sp. Ethington and Clark, 1964, p. 692, Pl. 113, figs. 6, 8, 10, 11, 14.

*Oistodus longiramis* Lindström. Ethington and Clark, 1964, p. 693, Pl. 114, figs. 2, 7.

non *Gothodus communis* Ethington and Clark. Ethington and Clark, 1965, Pl. 1, fig. 21.

non *Gothodus communis* Ethington and Clark. Ethington and Clark, 1971, Pl. 2, fig. 24.

non *Gothodus communis* Ethington and Clark. Sweet, Ethington and Barnes, 1971, Pl. 1, fig. 27.

*Prioniodus evae communis* (Ethington and Clark). McTavish, 1973, p. 45 (part), Pl. 3, fig. 32, text-fig. 6:e (non Pl. 3, figs. 27, 29-31, text-fig. 6:a-d).

*Prioniodus* (*Oepikodus*) *communis* (Ethington and Clark). Serpagli, 1974, text-fig. 15:G-I.

*Prioniodus* (*Oepikodus*) *intermedius* Serpagli, 1974, pp. 69-73, Pl. 15, figs. 1a-4b; Pl. 27, figs. 1-7; Pl. 31, figs. 2a-6 (includes additional synonymy).

*Remarks*: Elements of *O. communis* appear to be difficult to separate from those described under *O. intermedius* Serpagli. Klapper *et al*. (1977) have erred in suggesting that *O. communis* is the ancestral species, and that both *O.*

*intermedius* and *O*. *evae* evolved from it. Enough material is not at hand to discuss the problem of *O*. *intermedius* and *O*. *communis*, and the former is included in with the synonymy of *O*. *communis*.

*Occurrence*: Upper part of the Broken Skull Formation and basal Sunblood Formation.

*Material*: Prioniodiform elements 11, oepikodiform elements 21, oistodiform elements 12.

*Illustrated Material*: GSC50063, GSC50347, GSC50348, GSC50062, GSC50349, GSC50350, GSC50351, GSC50066, GSC50352, GSC50353, GSC50063, GSC50354, GSC50061

### Genus Oistodus Pander, emend. Van Wamel, 1974

Type species: Oistodus lanceolatus Pander, 1856

Synonyms:

Oistodus Pander, 1856, p. 27.
Oistodus Pander, emend. Lindström, 1955, p. 572.
Oistodus Pander, emend. Lindström, 1971, p. 35.

Remarks: According to Lindström's (1971) last redefinition of the genus, only hyaline conodonts should be included. However, hyaline specimens of the type species often occur together with similar non-hyaline elements. Furthermore, the symmetry transitions characteristic for Oistodus lanceolatus Pander, emend. Lindström, 1971, is present in conodonts such as Oistodus papiliosus (Van Wamel, 1974). As a consequence, it was suggested by Van Wamel (op. cit.) that the genus Oistodus be redefined to include both hyaline and cancellate conodonts.

Oistodus-like morphology is dominant throughout the Ordovician Period and individual oistodiform elements are associated with apparatuses of a number of multielement taxa. For these reasons, Oistodus and/or oistodiform elements have to be treated individually, sometimes as multielement and sometimes as form taxa.

Oepikodus evae (Lindström), emend. Van Wamel

(Pl. 2, fig. 21; Pl. 3, figs. 1-3, 17; Pl. 4, figs. 1-3)

Prioniodus evae Lindström, 1955, p. 589, Pl. 6, figs. 4-10; emend. Lindström, 1971, p. 52, figs. 13, 14; emend. Van Wamel, 1974, p. 74, Pl. 6, figs. 15-17.

Oepikodus smithensis Lindström, 1955, p. 570, Pl. 5, figs. 36, 37.

Oistodus longiramis Lindström, 1955, p. 579, Pl. 4, figs. 35-37.

Prioniodus (Oepikodus) evae Lindström. Serpagli, 1974, p. 67, Pl. 15, figs. 9a-13; Pl. 26, figs. 1-10; Pl. 31, fig. 1 (see for additional synonymy).

Prioniodus evae Lindström, Landing, 1976, p. 638, Pl. 4, figs. 1-5.

Occurrence: From the Road River Formation at Section K.

Material: Oistodiform elements 6, oepikodiform elements 13, prioniodiform elements 9.

Illustrated Material: GSC50216, GSC50877, GSC50878, GSC50879, GSC50880, GSC50891, GSC50892, GSC50893

## "Oistodus" cambricus Miller s.f.

(Pl. 1, fig. 17)

Oistodus cambricus Miller, 1969, p. 431, Pl. 66, figs. 8-12, text-fig. 5A.

Remarks: Except for the highly compressed state of the element, the unit is identical to O. cambricus Miller.

Occurrence: Sample K715:218 of the Rabbitkettle Formation.

Material: 1 specimen

Illustrated Material: GSC50018

## Oistodus inaequalis Lindström s.f.

(Pl. 12, fig. 11)

Oistodus inaequalis Lindström, 1955, not Pander, 1856, Lindström, 1955, p. 576, Pl. 3, figs. 53, 54, 57, not figs. 52, 55, 56.

Remarks: The form species O. inaequalis Lindström has been recently grouped into the multielemental taxon Paltodus subaequalis Pander (Klapper et al., 1977). This has temporarily resolved the problem of Drepanoistodus inaequalis sensu Van Wamel and D. inconstans sensu Lindström, both of which share O. inaequalis as a common factor. However, I find it best to treat the species as a form-taxon as none of the accompanying elements from the above multielement taxa are present.

Occurrence: Middle part of the Broken Skull Formation.

Material: 4 specimens

Illustrated Material: GSC50315

### *Oistodus lanceolatus* Pander

(Pl. 2, fig. 20; Pl. 12, figs. 1-3)

*Oistodus lanceolatus* Pander, 1856, p. 27, Pl. 2, figs. 17-19; Lindström, 1955 , p. 577, Pl. 3, figs. 58-60.

*Oistodus lanceolatus* Pander, emend. Lindström, 1971, p. 38; emend. Van Wamel, 1974, p. 75, Pl. 1, figs. 15-17.

*Oistodus triangularis* Lindström, 1955 , p. 591, Pl. 5, figs. 45, 46.

*Oistodus delta* Lindström, 1955 , p. 573, Pl. 3, figs. 3-9.

*Remarks*: As pointed out by Van Wamel (1974), some elements of *O. lanceolatus* may be cancellate.

*Occurrence*: Elements of *O. lanceolatus* are sporadically distributed through several collections from the Broken Skull Formation and a few from the Road River Formation at Section K.

*Material*: Triangulariform elements 5, deltaform element 1, oistodiform elements 15.

*Illustrated Material*: GSC50874, GSC50040, GSC50039, GSC50042

## Oistodus nevadensis Ethington and Schumacher s.f.

(Pl. 23, fig. 6)

Oistodus nevadensis Ethington and Schumacher, 1969, pp. 467, 468, Pl. 68, figs. 1-4, text-fig. 5C.

Remarks: This species appears to be diagnostic of late Chazyan - early Blackriveran collections from the Mackenzie Platform. In an unpublished study, Votaw (1971) suggested that this form may be one of the components of Belodella erecta (Rhodes and Doneley), described elsewhere in this thesis. Although the stratigraphic range of O. nevadensis is the same as Belodella erecta, the former taxon usually has a larger size.

Occurrence: Noted above.

Material: 31 specimens

Illustrated Material: GSC50160

### Oistodus pseudoramis Serpagli s.f.

(Pl. 12, figs. 12, 13)

Oistodus pseudoramis Serpagli, 1974, pp. 55, 56, Pl. 13, figs. 7a-10b; Pl. 23, figs. 10-12.

Discussion: The oistodiform element occurring in the collections resembles O. pseudoramis s.f., except that the unit seems to have a sharper antero-basal angle and a shorter posterior process. Although Serpagli noted that the antero-basal angle should be 55°, his illustrated specimen (Pl. 23, fig. 12) does not bear this out. The presence of an anticusp and the identical shape of the basal cavity allows me to include my specimens in this taxon.

Occurrence: Elements belonging to this species may have a much wider distribution than presently known (e.g. the oistodiform element of Drepanoistodus inconstans (Lindström) may belong here). The species occurs sporadically through the lower and middle parts of the Broken Skull Formation, although some broken specimens from the upper parts of this Formation included under Oepikodus communis also look quite similar.

Material: 7 specimens

Illustrated Material: GSC50316, GSC50317

### Oistodus scalenocarinatus Mound

(Pl. 16, figs. 1-3)

Oistodus scalenocarinatus Mound, 1965, p. 30, Pl. 4, figs. 6, 7, 10-12; Barnes, 1977, p. 103, Pl. 1, figs. 11-13 (includes additional synonymy).

Remarks: Recently Barnes (1977) attempted to separate the two similar multielemental taxa Oistodus multicorrugatus Mound and O. scalenocarinatus Mound. He pointed out that elements of the latter species include a costate symmetry transition series consisting of cordylodiform, cladognathiform and hibbardelliform elements, and that their bases are generally flat to bowed downwards and elongate posteriorly. Several elements of these types are present in my collections and hence are included in O. scalenocarinatus. No hibbardelliform element was found.

Occurrence: Sporadically in the upper Broken Skull Formation, basal Sunblood Formation at Section H and some Whiterockian collections.

Material: Cordylodiform elements 8, cladognathiform elements 7.

Illustrated Material: GSC50369, GSC50370, GSC50371

### Oistodus venustus Stauffer s.f.

(Pl. 4, fig. 8)

Oistodus venustus Stauffer, 1935, pp. 146, 159, Pl. 12, fig. 12; Bergström and Sweet, 1966, pp. 341, 342, Pl. 35, figs. 20, 21 (includes synonymy through 1966); Winder, 1966, Pl. 9, fig. 12; Weyant, 1968, p. 53, Pl. 2, fig. 9; Bradshaw, 1969, p. 1158, Pl. 134, figs. 4-7; Sweet et al., 1975, Pl. 1, fig. 9.

Remarks: Suggestions have been made that elements of O. venustus belong to either a drepanoistodid apparatus (Lindström, 1971, p. 43; Serpagli, 1974, p. 47) or a paroistodid apparatus, Barnes and Poplawski (1973). At present there is no definite status for this form, which is dealt here in form-taxonomy.

Occurrence: Rare in the Road River Formation. No specimen was recovered from the carbonates of Southern Mackenzie Platform.

Material: 2 specimens

Illustrated Material: GSC50294

## Oistodus n. sp. 1 s.f.

(Pl. 16, fig. 6)

Description: An oistodiform element distinguished by its large size, small and narrow base, and large robust cusp that has its maximum width above the midpoint from where its anterior margin curves distally to meet the posterior margin at about a 45° angle. The unit occurs with elements of Triangulodus robustus (Serpagli). The relatively narrow base, shallow basal cavity, and large cusp are common to the drepanodiform and oistodiform elements of T. robustus. It is possible, therefore, that the present form may be an oistodiform element of T. robustus.

Occurrence: Basal Sunblood Formation at Section H.

Material: 1 specimen

Illustrated Material: GSC50373

## Oistodus cf. O. n. sp. 1 Serpagli

(Pl. 12, figs. 7-10)

cf. Oistodus n. sp. 1 Serpagli, 1974, pp. 53, 54, Pl. 12, figs. 2a-3c (only); Pl. 24, figs. 2, 4 (only); text-fig. 11 (in part).

Remarks: Serpagli (1974) illustrated and described elements of a new Oistodus species, Oistodus sp. 1 Serpagli, that show a symmetry transition similar to Oistodus lanceolatus Pander. All elements appear to bear a tall, sharp-edged cusp which is considerably larger than the base.

My collections include several elements that are similar to, but not conspecific with, the symmetrical costate to acostate forms noted in the synonymy. However, none of the specimens have a tall cusp, and the base is large relative to the cusp. This latter feature is also found in the oistodiform element of Acodus ? russoi Serpagli, but the unit is asymmetric. Rather than describing these elements individually, I have included them with some hesitancy in Serpagli's species. These triangulariform elements show a symmetry transition from well costate to poorly costate forms. All appear to be of the same size.

Occurrence: Sporadically through the Broken Skull Formation, middle part.

Material: 12 specimens

Illustrated

Material: GSC50311, GSC50312, GSC50313, GSC50314

### Oistodus ? striolatus Serpagli

(Pl. 12, figs. 5, 6)

Oistodus striolatus Serpagli, 1974, p. 57, Pl. 12, figs. 5a-9b; Pl. 24, figs. 5-7.

Remarks: The chief feature of the oistodiform elements included in this species is the presence of fine striations on the basal part of the unit. Otherwise there is little difference between it and O. multicorrugatus sensu Serpagli, 1974. A few elements that conform to this definition occur in samples from the Broken Skull Formation that contain elements of O. lanceolatus. Elements from the present collections generally possess a shorter posterior and longer (stretched) anterior process.

Occurrence: Broken Skull Formation, middle part.

Material: 7 specimens

Illustrated Material: GSC50309, GSC50310

### Oistodus ? sp. aff. O. sp. Serpagli s.f.

(Pl. 12, fig. 4)

aff. Oistodus ? sp. Serpagli, 1974, pp. 57, 58, Pl. 12, figs. 4a,b; Pl. 24, fig. 11; Pl. 30, figs. 9a,b.

Remarks: A few oistodiform elements that bear tall, suberect cusps, sharp posterior and anterior margins, and a short base but lack the fine striations exhibited by the Argentinian specimens described by Serpagli, are included under Oistodus ? sp. aff. O. sp. Serpagli. The specimen illustrated here also has a less developed anticusp. This form is questionably assigned to Oistodus because of the somewhat scandodiform nature of the elements.

Occurrence: Broken Skull Formation, middle part.

Material: 3 specimens

Illustrated Material: GSC50808

### Oistodus spp. s.f.

(Pl. 18, figs. 8, 14)

Remarks: A few hyaline oistodiform elements occur in the Whiterockian collections from the Sunblood Formation. At present, it is not possible to include them in multielement taxa with any other elements from the same collection. They range from rather delicate narrow elongated forms (Pl. 18, fig. 14) to those that are short and robust (Pl. 18, fig. 8). Stratigraphically, the short, robust ones occur with *M. subdentatus*, and the elongated elements are usually associated with New Genus New Species D.

Occurrence: As noted above.

Material: Elongate forms 7, short robust forms 9.

Illustrated Material: GSC50097, GSC50417

### Genus Oneotodus Lindström, 1955

Type species: Distacodus ? simplex Furnish, 1938

Definition: Lindström defined this genus as simple cones, with a well-defined basal cavity and the cusp unkeeled and subcircular in cross-section. Its multielemental status is yet unknown.

### Oneotodus erectus Druce and Jones s.f.

(Pl. 2, fig. 2)

Oneotodus erectus Druce and Jones, 1971, pp. 80-81, Pl. 15, figs. 2a-9, text-fig. 26d.

Occurrence: From the Rabbitkettle Formation, K880:268.

Material: 1 specimen

Illustrated Material: GSC50865

## Oneotodus gracilis (Furnish) s.f.

(Pl. 2, figs. 4, 5)

Distacodus ? gracilis Furnish, 1938, pp. 12, 327, Pl. 42, fig. 23.

Oneotodus simplex (Furnish), Ethington and Clark, 1964, p. 695, Pl. 114, fig. 13.

Oneotodus gracilis (Furnish), Moskalenko, 1967, p. 111, Pl. 24, figs. 3, 4; Druce and Jones, 1971, p. 82, Pl. 14, figs. 9a-13b; Pl. 15, figs. 1a-c; text-fig. 26h.

Remarks: Included here are long slender oneotodids with a large cone-shaped basal cavity, with the cusp erect to reclined at angles of up to 45°. They are translucent, except for a thin column of 'white matter' developed along the growth axis. The cusp is three to four times as long as the base is broad.

Occurrence: From the upper collections of the Rabbitkettle Formation.

Material: 8 specimens

Illustrated Material: GSC50866, GSC50867

### *Oneotodus nakamuri* Nogami s.f.

(Pl. 1, figs. 19, 20)

*Oneotodus* sp. A Müller, 1959, p. 458, Pl. 13, fig. 17.

*Oneotodus nakamuri* Nogami, 1967, pp. 216-217, Pl. 1, figs. 9, 12, text-fig. A, *non* Pl. 1, figs. 10, 11, 13; Miller, 1969, pp. 435-436, Pl. 63, figs. 1-9, text-fig. 5E; Druce and Jones, 1971, pp. 82-83, Pl. 10, figs. 3, 4, 8, text-figs. 26i, j, *non* Pl. 10, figs. 1, 2, 5-7; Jones, 1971, p. 58, Pl. 4, figs. 1, 3, 4, *non* Pl. 4, fig. 2; Müller, 1971, p. 17, fig. 1e; Müller, 1973, p. 41, Pl. 5, fig. 4.

*Oneotodus simplex* (Furnish), Miller, 1971, p. 80, Pl. 2, figs. 1-5.

*Distacodus* ? *simplex* Furnish, 1938, p. 328, Pl. 42, figs. 24, 25, text-fig. 10.

*Remarks*: Miller (1971), commenting on the Trempealeauan conodonts from Wisconsin noted that *O. nakamuri* cannot always be easily distinguished from *O. simplex* (Furnish), and considered them synonymous. I have likewise done so because the majority of the oneotodids present in my collections are poorly preserved.

*Occurrence*: Rabbitkettle Formation, upper part.

*Material*: 7 specimens

*Illustrated Material*: GSC50017, GSC50863

### Oneotodus n. sp. A s.f.

(Pl. 2, figs. 1, 3)

Diagnosis: Minute oneotodids showing a minor variation in the curvature of the posterior cusp from sharply curved to almost erect.

Description: The sharply curved elements tend to develop an elliptical basal opening and a low carina on the inner anterior margin (Pl. 2, fig. 1). The less curved units, although broken towards the base, probably have a circular basal opening. The depth of the basal cavity cannot be judged, although it is suspected that it extends to the bend of the cusp.

Remarks: The two elements of Oneotodus n. sp. A co-occur in the samples K880:268 and K995:303. They are of the same size and can easily be separated from elements belonging to Oneotodus nakamuri Nogami.

Occurrence: From the Cordylodus proavus Zone (K880:268 and the younger sample K995:303).

Material: 21 specimens

Illustrated Material: GSC50020, GSC50864

## Genus Oulodus Branson and Mehl, 1933

Oulodus Branson and Mehl, 1933, p. 116.

Cyrognathus Stauffer, 1935, p. 144.

Type species: Oulodus mediocris Branson and Mehl, 1933

Remarks: Oulodus was established as a form-genus by Branson and Mehl (1933) for elements consisting of an asymmetric arched and twisted denticulate bar with unequal denticulate lateral processes. Bergström and Sweet (1966) recognized that Oulodus was a multielement genus in which early species developed oulodiform and cordylodiform elements and later species added prioniodiniform elements. The composition of the skeletal apparatus was further expanded to include eoligonodiniform elements in some species of Oulodus (Kohut and Sweet, 1968). More recently, Sweet and Schönlaub (1975) redefined Oulodus as consisting of a symmetry transition series of trichonodelliform-zygognathiform, cordylodiform and two additional elements (one the prioniodiniform or oulodiform, and the other the cyrtoniodiform or prioniodiniform elements). These elements were provided with letter symbols. I have not used this system as my Oulodus species probably is incompletely represented and occurs at a stratigraphic position where little differentiation has taken place.

## Oulodus n. sp. A

(Pl. 21, figs. 1-12)

Diagnosis: A multielemental species of Oulodus consisting of oulodiform, prioniodiniform (?), trichonodelliform, cyrtoniodiform and neoprioniodiform elements. All elements bear slender, discrete denticles and have a flared base.

Remarks: The inclusion of neoprioniodiform elements is new to the apparatus, but recently Nicoll (1977) has suggested its presence for a Silurian Oulodus species. As interpreted here, the apparatus is incomplete. Some oulodiform elements show a chirognathiform morphology.

Description: The oulodiform element of this species is highly variable. The cusp is usually slender and compressed, but in some forms it is moderately stout, with a subrounded cross section. It is seldom straight and is usually inclined towards one side. In rare instances it is long, although it is usually moderate in size. The two lateral processes are also highly variable, and range from subequal downwardly directed processes to mere extensions of the cusp. They seldom lie on the same plane as the cusp. The denticles are usually slender and compressed and most tend to be discrete. The bases of these elements express the most consistent feature; highly flared into a subrounded opening under the cusp, narrowing underneath the processes.

The cyrtoniodiform elements are quite distinct (Pl. 21, figs. 9, 12). One of these (fig. 9) vaguely resembles the prioniodiniform element of Plectodina aculeata, whereas the other is more similar to homologous elements of younger oulodids.

The trichonodelliform elements are close to homologous elements of Plectodina aculeata. They appear to be smaller in size and bear shorter processes.

Prioniodiniform elements are impossible to single out. One element (Pl. 21, fig. 2) is questionably included here. The cusp and denticles of this element are relatively stout.

A distinctive neoprioniodiform? element (Pl. 21, figs. 4, 8), with a tall, inclined cusp, a long anterior (?) process and short posterior (?) process, usually occurs with the oulodiform elements. Although neoprioniodiform elements were not included by Sweet and

Schönlaub (1975) in their apparatus of *Oulodus*, Nicoll (1977) has suggested their possible presence in a Silurian *Oulodus* apparatus, based on a gastric assemblage. The inclusion of these neoprioniodiform elements in this apparatus is supported by the latter study.

Occurrence: Lower Chazyan collections from Section B.

Material: Oulodiform elements 18, cyrtoniodiform elements 7, trichonodelliform elements 7 , neoprioniodiform elements 7, prioniodiniform element ? 1.

Illustrated Material: GSC50453, GSC50454, GSC50455, GSC50456, GSC 50457, GSC50458, GSC50459, GSC50460, GSC50461, GSC50462, GSC50463, GSC50738

### Genus Paltodus Pander, 1856

Type species: Paltodus subaequalis Pander, 1856

### "Paltodus" utahensis ? Miller s.f.

(Pl. 1, fig. 15)

?Paltodus utahensis Miller, 1969, pp. 436-47, Pl. 63, figs. 39, 40, non figs. 33-38, text-fig. 5F.

Remarks: Tentatively included here is one specimen that is laterally compressed and asymmetrical. It fits the description of this species, and resembles the figured specimens of Miller (1969) noted above in synonymy. The element at hand is, however, more asymmetric.

Occurrence: In the Rabbitkettle Formation, K715:218.

Material: 1 specimen

Illustrated Material: GSC50860

## Genus Panderodus Ethington, 1959

Type species: Paltodus unicostatus Branson and Mehl, 1933

### Panderodus gracilis (Branson and Mehl)

(Pl. 7, figs. 16,17; Pl. 23, figs. 13,16,18; Pl. 26, figs. 16,22,23,24)

Paltodus gracilis Branson and Mehl, 1933, p. 108, Pl. 8, figs. 20, 21.

Panderodus gracilis (Branson and Mehl). Uyeno, 1974, p. 15, Pl. 3, figs. 7-14 (includes synonymy to 1974); Sweet, Thompson and Satterfield, 1975, Pl. 1, figs. 7, 8.

Panderodus gracilis (Branson and Mehl). Barnes, 1977, p. 107, Pl. 3, figs. 6, 7.

Remarks: Barnes noted that the Late Ordovician forms of the P. gracilis s.f. element are more slender, longer and more sharply recurved at a point farther toward the tip than forms from the Middle Ordovician. In this context, I now believe that P. gracilis is the only panderodid represented in rocks of the Road River Formation, and is also widespread through most of the Chazy, Blackriveran and younger rocks from the Southern Mackenzie Region (Sunblood and Esbataottine and Whittaker Formations).

Occurrence: As noted above.

Material: Over 530 specimens

Illustrated Material: GSC50245, GSC50246, GSC50165, GSC50492, GSC50493, GSC50186, GSC50187, GSC50188, GSC50189

## Genus Paracordylodus Lindström, 1955

Type species: *Oistodus gracilis* Lindström, 1955

Remarks: At present this genus is interpreted as a multielement genus that includes cordylodiform as well as oistodiform elements. An additional cyrtoniodiform (cordylodiform) element was postulated by Van Wamel (1974) and Barnes and Poplawski (1973). Although not present in the study area, I have noted cyrtoniodiform elements in a collection recently given to me by B.D.E. Chatterton that could well belong to this apparatus.

### Genus Paracordylodus Lindström, 1955

Type species: Oistodus gracilis Lindström, 1955

Remarks: At present this genus is interpreted as a multielement genus that includes cordylodiform as well as oistodiform elements. An additional cyrtoniodiform (cordylodiform) element was postulated by Van Wamel (1974) and Barnes and Poplawski (1973). Although not present in the study area, I have noted cyrtoniodiform elements in a collection recently given to me by B.D.E. Chatterton that could well belong to this apparatus.

## Paracordylodus gracilis Lindström

(Pl. 12, fig. 14)

Oistodus gracilis Lindström, 1955 , p. 576, Pl. 5, figs. 1, 2; Lamont and Lindström, 1957, p. 62; Lindström, 1960, text-fig. 1 (II 2); Ethington, 1972, p. 24, Pl. 1, fig. 8.

Paracordylodus gracilis Lindström, 1955 , pp. 584, 585, Pl. 6, figs. 11, 12; Lamont and Lindström, 1957, p. 62; Lindström, 1960, text-fig. 1 (II 3); Lindström, 1964, text-fig. 51e; emend. Sweet and Bergström, 1972, p. 33, text-fig. 2D; Ethington, 1972, p. 24, Pl. 1, fig. 4; Bergström et al., 1972, p. 38, text-figs. 1g,h; emend. Barnes and Poplawski, 1973, pp. 778, 779, Pl. 1, figs. 6-8; Serpagli, 1974, pp. 60, 61, Pl. 24, figs. 14-16, Pl. 31, figs. 7a-8, text-fig. 13; Van Wamel, 1974, pp. 77, 78, Pl. 4, figs. 11-13; Landing, 1976, pp. 634, 635, Pl. 2, fig. 18.

Occurrence: Several oistodiform elements of this species are found in the Broken Skull Formation in one collection, D555:169. However, none of the other two elements were found to co-occur in this sample. Two oistodiform elements and possibly one cordylodiform element are present in the Road River Formation, K2050:625. Some of the oistodiform elements show surface microornamentation similar to Oepikodus evae Lindström.

Material: 16 specimens

Illustrated Material: GSC50318

## Genus Paroistodus Lindström, 1971

Type species: Oistodus parallelus Pander, 1856

Definition: "Paroistodus includes drepanodid conodonts with drepanodiform and oistodiform elements. The basal cavity tends to become inverted anteriorly. Drepanodiform elements tend to develop a sharp, low costa on each side. The base of oistodiform elements is roughly square in side view and does not extend very far anteriorly" (Lindström, 1971, p. 46). Van Wamel (1974) emended it to include, in addition to drepanodiform and oistodiform elements, a slightly asymmetrical form with a basal cavity opening to one side (scandodiform elements).

Remarks: Lindström assigned four species to this genus, namely P. numarcuatus, P. proteus, P. parallelus and P. originalis, and assigned them different stratigraphic positions based upon different morphologic criteria. Both Van Wamel (1974) and Landing (1976) questioned this, especially the differences between the oistodiform elements of the four species. Van Wamel, in fact, placed P. numarcuatus in Drepanoistodus. He combined all the other three into one species, Paraoistodus proteus. Van Wamel's decision for combining the three species into one has some validity for collections beyond the Öland region, as both Serpagli (1974) and Landing (1976) also expressed similar uncertainty regarding this genus and the various species assigned to it. Serpagli (1974) recognized only one species, P. parallelus, and stated that not all the drepanodiform elements carried the lateral costa that are diagnostic of this species sensu Lindström, 1971. I have followed Serpagli (1974) in recognizing P. parallelus as the only one of these species that can be recognized.

## *Paroistodus amoenus* (Lindström) *sensu* Van Wamel, 1974

(Pl. 13, figs. 1-3)

*Drepanodus amoenus* Lindström, 1955, p. 588, Pl. 2, figs. 25, 26; Fig. 4b.

*Oistodus parallelus* Pander, Lindström, 1955, p. 579, Pl. 4, figs. 27-29; Fig. 3N, *not* Pl. 4, figs. 26, 30, 31; Fig. 30.

*Paroistodus numarcuatus* (Lindström) pars, emend. Lindström, 1971, p. 46, fig. 8.

*Paroistodus amoenus* (Lindström), emend. Van Wamel, 1974, pp. 78, 79, Pl. 7, figs. 8-11.

Remarks: Van Wamel (1974) differentiated the drepanodiform element of this species, namely *D. amoenus* Lindström, from two similar species, *D. sculponea* Lindström and *D. proteus* [the former (*D. sculponea*) is included in with *Drepanodus arcuatus*, whereas the latter (*D. proteus*) is an element of *Paroistodus parallelus*]. These differences are extremely difficult to determine, and in the collections from the Broken Skull Formation, it is not possible to distinguish between drepanodiform elements of *P. amoenus* and *Drepanodus arcuatus*, as the basal cavities cannot be seen. The oistodiform element of *P. amoenus*, however, is sufficiently different from those of *P. parallelus* (namely thinner, more delicate, with a smaller base-to-cusp ratio and a large base-to-cusp angle; also noted by Van Wamel, 1974).

Occurrence: Oistodiform elements of Paroistodus amoenus are well represented in the lower Broken Skull Formation.

Material: 41 oistodiform elements

Illustrated Material: GSC50034, GSC50320, GSC50321

Paroistodus parallelus (Pander) sensu Serpagli, 1974

(Pl. 3, fig. 7; Pl. 7, fig. 10; Pl. 13, figs. 7, 8, 11, 17, 18, 20)

Oistodus parallelus Pander, 1856, p. 27, Pl. 2, fig. 40.

Paroistodus parallelus (Pander), emend. Lindström, 1971, p. 47, figs. 8, 11.

Drepanodus proteus Lindström, 1955, p. 556, Pl. 3, figs. 18-21, figs. 2a-f, j.

Oistodus originalis Sergeeva, 1963, p. 98, Pl. 7, figs. 8, 9.

Paroistodus originalis (Sergeeva), emend. Lindström, 1971, p. 48, figs. 8, 12.

Distacodus expansus (Graves and Ellison). Lindström, 1955, p. 555, Pl. 3, figs. 13-17.

Paroistodus parallelus (Pander), Van Wamel, 1974, pp. 79, 80, Pl. 7, figs. 12-17; Serpagli, 1974, pp. 61, 62, Pl. 14, figs. 8-12b, Pl. 30, fig. 3; Landing, 1976, p. 635, Pl. 3, figs. 1, 2.

Remarks: Serpagli (1974), Van Wamel (1974) and Landing (1976) have noted the problem of 'transients' between drepanodiform elements of P. parallelus and P. originalis. Added to this problem is the confusion between drepanodiform elements of P. parallelus and those belonging to Drepanodus arcuatus (especially the sculponea type), especially if the basal cavities are not distinguishable (which is the case here).

Occurrence: Elements of this species have been recovered from the Broken Skull Formation, basal Sunblood Formation at

Section H and the Road River Formation. Those from the Road River Formation are recognized as sensu lato.

Material: Oistodiform elements 45, drepanodiform elements 79.

Illustrated Material: GSC50209, GSC50919, GSC50333, GSC50334, GSC50721, GSC50336, GSC50337, GSC50338

## Genus *Periodon* Hadding, 1913

*Type species:* *Periodon aculeatus* Hadding, 1913

*Remarks:* This genus, as emended by Bergström and Sweet (1966), includes prioniodiform, periodontiform (cordylodiform, ligonodiniform, cladognathodiform, hibbardelliform) and falodiform elements.

Serpagli (1974) presented a summary of this genus and its three species, namely *P. flabellum*, *P. aculeatus* and *P. grandis*. Noting that the oistodiform (falodiform) element is notably different for each of these three species, Serpagli tried to present these differences by means of sketches (see Serpagli, 1974, p. 65, text-fig. 14). He did not provide any written description. As far as I can see from my collections, these three species cannot be confidently separated (see also Bergström and Sweet, 1966). However, minor differences are present, one of which I believe involves the relationship of the size and shape of the denticles with respect to both one another and to the cusp. For instance, I believe that periodontiform elements of *P. aculeatus* Hadding *sensu* Uyeno and Barnes (1970) probably are *not* conspecific with *P. aculeatus* s.s. In size and shape, the denticles appear to be shorter, somewhat stubbier and more confluent, and the cusp is usually shorter than the one found in homologous elements of *P. aculeatus* s.s. Moreover, the oistodiform (falodiform) element contains only up to two anterior denticles (including some that are adentate). I have deliberated on this point, namely whether to refer to the species *P. aculeatus sensu* Uyeno and Barnes as a new species or subspecies or to keep it within the original species *P. aculeatus*. After much thought I have decided to refer to *P. aculeatus sensu* Uyeno and Barnes as an early form of *P. aculeatus*. It is of some interest to note that in the interval studied by Uyeno and Barnes, the oistodiform (falodiform) element without anterior denticles is restricted only to the lower collections, whereas the denticulate ones occur throughout the collections. Possibly, the *Periodon* species studied by Uyeno and Barnes includes both early and 'stable' components of *P. aculeatus*.

Like Serpagli (1974), I believe that the stratigraphic position of a *Periodon* fauna can be predicted on the basis of the falodiform element.

In the Mackenzie collections, I have identified four such positions. The identification of *P. flabellum* is least certain because the falodiform element is not present. However, the cordylodiform and ozarkodiniform elements found in the collection are similar to those of *P. flabellum*. Moreover, the stratigraphic age falls within the range of that species (lower Middle Arenigian). The next species, *P. aculeatus* (early form) *sensu* Uyeno and Barnes, is believed to be somewhat older than *P. aculeatus* Hadding. Reasons for this have been noted earlier.

An additional point is that of the obvious age difference between the two. P. aculeatus (early form) sensu Uyeno and Barnes is probably late Arenigian or early Llanvirnian, whereas P. aculeatus Hadding, as reported from another locality, is Llandeillian in age. The latter co-occurs with Pygodus serrus (Hadding). The former species may be identical to P. aculeatus zgierzensis Dzik illustrated by Dzik (1976) from the lower Llanvirnian of Poland.

The youngest Periodon species is P. grandis. It occurs in conjunction with Amorphognathus superbus and is therefore late Middle to early Late Ordovician in age. I have included in the apparatus of P. grandis a new cyrtoniodiform element. This element in all probability is a variant of the prioniodiniform element wherein the anterior denticles have become reduced. The prioniodiniform element also in this instance has a somewhat more robust and 'mature' appearance, and bears fewer denticles when compared to similar elements of this species from other regions (see Bergström and Sweet, 1966).

### *Periodon aculeatus* Hadding

(Pl. 4, figs. 11 - 16; Pl. 6, figs. 11, 12)

*Periodon aculeatus* Hadding, 1913, p. 33, Pl. 1, fig. 14; Bradshaw, 1969, pp. 1159-1160, Pl. 137, figs. 1-6 (includes synonymy through 1968; non Winder, 1966, p. 50, Pl. 10, fig. 25); Uyeno and Barnes, 1970, p. 112, Pl. 23, figs. 1-7 (early form); Barnes and Poplawski, 1973, pp. 780, 781, Pl. 5, figs. 15-18a; Landing, 1976, pp. 636, 637, Pl. 3, figs. 3-6, 14.

*Ozarkodina macrodentata* Graves and Ellison, 1941, pp. 5, 7, 14, Pl. 2, figs. 33, 35, 36.

*Oistodus prodentatus* Graves and Ellison, 1941, pp. 13, 14, Pl. 2, figs. 6, 22, 23-28.

*Falodus prodentatus* (Graves and Ellison). Sweet and Bergström, 1962, pp. 1227-1228, Pl. 170, figs. 2, 3, text-fig. 2B (included synonymy through 1961); Hamar, 1964, p. 265, Pl. 4, figs. 9, 10, text-fig. 2B; Sweet and Bergström, 1966, p. 151, Pl. 18, fig. 7; Bradshaw, 1969, p. 1151, Pl. 135, figs. 16, 17; Uyeno and Barnes, 1970, p. 108, Pl. 22, figs. 8, 14, 18 (early form).

*Ligonodina tortilis* Sweet and Bergström, 1962, pp. 1230-1231, Pl. 170, figs. 13, 14.

*Prioniodina macrodentata* (Graves and Ellison). Sweet and Bergström, 1962, p. 1240, Pl. 171, figs. 7, 8; Hamar, 1964, p. 278, Pl. 3, fig. 28, text-fig. 4, n. 19; Sweet and Bergström, 1966, p. 151, Pl. 18, fig. 9, text-fig. 1A,F; Bradshaw, 1969, p. 1160, Pl. 137, fig. 19; Uyeno and Barnes, 1970, p. 113, Pl. 23, figs. 12, 16 (early form).

?*Oistodus bilongatus* Harris, 1962, pp. 201-202, Pl. 1, figs. 8, 9a,b, 10a-c.

Falodus sp. Uyeno and Barnes, 1970, p. 110, Pl. 22, fig. 15 (early form).

?Eofalodus brevis Harris, 1962, pp. 205-206, Pl. 1, figs. 7a-d.

Periodon aculeatus zgierzensis Dzik, 1976, p. 424, text-fig. 34e-k, Pl. XLIV, figs. 5-6 (early form).

Occurrence: Elements of P. aculeatus (Hadding) sensu Uyeno and Barnes represented by the notation (early form) occur in the Road River Formation at Section K (K2375:724). Elements of P. aculeatus s.s. occur in the Road River Formation at Locality 5.

Material: P. aculeatus (early form)

Falodiform elements 29, periodontiform elements 61, prioniodiniform elements 5.

P. aculeatus s.s.

Falodiform elements 5, periodontiform elements 11, prioniodiniform elements 3.

Illustrated Material: GSC50223, GSC50206, GSC50207, GSC50235, GSC50234, GSC50233, GSC50912, GSC50913

Periodon flabellum (Lindström), emend. Lindström, 1971

(Pl. 14, figs. 14, 15, 18)

Trichonodella flabellum Lindström, 1955, p. 599, Pl. 6, figs. 28-30.

Periodon flabellum (Lindström). Lindström, 1964, p. 83, figs. 28 A-D.

Prioniodina ? deflexa Lindström, 1955, p. 586, Pl. 6, figs. 31-35.

Prionidina inflata Lindström, 1955, p. 588, Pl. 6, figs. 26, 27.

Oulodus inflatus (Lindström). Lindström, 1964, p. 85, figs. 30 A-B.

Oistodus selene Lindström, 1955, p. 580, Pl. 4, figs. 19, 20.

Periodon flabellum (Lindström). Serpagli, 1974, pp. 63, 64, Pl. 14, figs. 1a-7b, Pl. 25, figs. 1-6 (includes synonymy through 1973); Van Wamel, 1974, pp. 80, 81, Pl. 4, figs. 14-20 ; Landing, 1976, pp. 636, 637, Pl. 3, figs. 7-10, 12, 15, 16 (not Pl. 3, fig. 11).

Remarks: As noted earlier, only the ozarkodiniform and eoligonodiniform elements are present.

Occurrence: Two eoligonodiniform elements were recovered from the Road River Formation at Section K (K2050;625) while rare ozarkodiniform and eoligonodiniform elements were present in the basal Sunblood Formation at Section H.

Material: Eoligonodiniform elements 6, ozarkodiniform elements 4

Illustrated Material: GSC50357, GSC50358, GSC50359

### Periodon grandis (Ethington)

(Pl. 6, figs. 4-6, 9)

Eoliogonodina magna Ethington, 1959, p. 277, Pl. 40, figs. 3, 4.

Loxognathus grandis Ethington, 1959, p. 281, Pl. 40, fig. 6.

?Loxognathus grandis Ethington, Hamar, 1964, pp. 267-268, Pl. 3, figs. 22, 24, 26, 27, text-figs. 4-15a,b.

?Paracordylodus bergstroemi Hamar, 1964, p. 273, Pl. 3, figs. 20, 23 (non Pl. 3, fig. 25).

?Periodon aculeatus Hadding, Hamar, 1964, p. 274, Pl. 3, figs. 17, 21.

Periodon aculeatus Hadding, Sweet and Bergström, 1962, p. 1235, Pl. 171, figs. 3, 9; Ethington and Clark, 1965, p. 198, Pl. 2, fig. 10; Winder, 1966, Pl. 10, fig. 25; Webers, 1966, pp. 57-58, Pl. 12, fig. 16; Schopf, 1966, pp. 67-68, Pl. 3, figs. 12, 14, ?10, 16 (non Pl. 3, fig. 13).

Periodon grandis (Ethington) Webers, 1966, p. 58, Pl. 12, fig. 8; Bergström and Sweet, 1966, pp. 363-365, Pl. 30, figs. 3, 4 (non Pl. 30, figs. 1, 2, 5-8); Sweet et al., 1975, Pl. 3, figs. 6, 16; Barnes, 1977, p. 107, Pl. 4, figs. 6, 7).

Occurrence: Elements of this species are present in some collections from the Road River Formation, especially Locality 2.

Material: Falodiform elements 3, periodontiform elements 5, prioniodiniform elements (includes cyrtoniodiform elements also) 7.

Illustrated Material: GSC50906, GSC50907, GSC50908, GSC50909

## Genus Phragmodus Branson and Mehl, 1933

Emend. Bergström and Sweet, 1966

Phragmodus Branson and Mehl, 1933, p. 98.

Type species: Phragmodus primus Branson and Mehl, 1933

Remarks: Bergström and Sweet (1966) have emended and discussed the multielement genus Phragmodus. The apparatuses of the two species and one subspecies of Phragmodus represented in the rocks studied are illustrated in stratigraphic order. Two other Phragmodus species, "Phragmodus" n. sp. A and Phragmodus n. sp. B, are treated in a multielemental sense while one phragmodiform element, Phragmodus n. sp. 1, is treated as form-taxon.

### Phragmodus flexuosus Moskalenko

(Pl. 22, figs. 1-11)

Phragmodus flexuosus Moskalenko, 1973, pp. 73, 74, Pl. 11, figs. 4-6; Barnes, 1977, p. 103, Pl. 2, figs. 3, 4.

Subcordylodus sinuatus Stauffer, Moskalenko, 1973, pp. 80, 81, Pl. 12, figs. 7-9a,b.

Gothodus evenkienis Moskalenko, 1973, pp. 67, 68, Pl. 11, figs. 1-3a,b.

Dichognathus decipiens Branson and Mehl. Moskalenko, 1973, pp. 66, 67, Pl. 15, figs. 7a,b, 8-12a,b.

Oistodus abundans Branson and Mehl. Moskalenko, 1973, pp. 35, 36, Pl. 1, figs. 8, 9.

Phragmodus sp. A Sweet, Ethington and Barnes, 1971, Pl. 2, figs. 3-6.

Phragmodus n. sp. Moskalenko, 1972, fig. 1 (1-12).

Phragmodus n. sp. A Barnes, 1974, Pl. 1, fig. 10.

Remarks: Several specimens of Phragmodus flexuosus, as described by Moskalenko (1972), are present in the Chazyan collections of the Sunblood Formation. Two additional forms have been illustrated and identified: the 'early form' and the 'late form'.

Elements of the 'early form' occur in the oldest collection of Phragmodus flexuosus. The elements possess robust cusps, have relatively few but stubby denticles that are somewhat 'twisted'. They may be highly sinuous, but this feature cannot be noted as the specimens are broken. The dichognathiform elements are adentate.

Elements of the 'late form' occur in one collection intermediate between those containing *P. flexuosus flexuosus* and *P. flexuosus symmetricus* Tipnis *et al.* (in press). In the 'late form' the cusp and the denticles are well compressed, sinuosity is present but less than in *P. flexuosus*, and the teeth are fused basally and confluent to a considerable distance apically. The dichognathiform elements are well denticulated and an additional cyrtoniodiform element appears to be present.

*Occurrence:* This species is very well represented throughout the Chazyan collections from the Sunblood Formation at Sections B and P and to a lesser extent in other sections.

*Material:* Phragmodiform elements 67, cordylodiform elements 82, dichognathiform elements 63, cyrtoniodiform elements 48.

*Illustrated Material:* GSC50472, GSC50473, GSC50725, GSC50474, GSC50475, GSC50476, GSC50117, GSC50477, GSC50125, GSC50478, GSC50479, GSC50739

Phragmodus flexuosus Moskalenko, 1973

Phragmodus flexuosus symmetricus Tipnis, Chatterton
and Ludvigsen, in press
(Pl. 22, figs. 12-15, 18-20 (?))

Diagnosis: A subspecies of Phragmodus flexuosus, with a phragmodiform element that has reduced flexing or twisting of the posterior blade and denticles that are comparatively fine, tightly packed, laterally compressed and project backwards or slightly above backwards.

Description: Like Phragmodus flexuosus flexuosus, P. flexuosus symmetricus consists of phragmodiform, cordylodiform, cyrtoniodiform and dichognathiform elements. Of these, the phragmodiform element is the most characteristic element, while the cordylodiform and cyrtoniodiform elements are very similar to those of P. flexuosus flexuosus. Of the two dichognathiform elements that are present in P. flexuosus flexuosus (Pl. 5, figs. 1 and 3), I have only found the latter form in association with the phragmodiform element of P. flexuosus symmetricus. The phragmodiform element consists of a medium to large-sized recurved cusp and a weakly twisted posterior blade that projects backward and downward. The cross section of the cusp varies from compressed (smooth lateral faces, sharp anterior and posterior edges) to oval. The cusp may be smooth and acostate, or bear a single longitudinal or even two longitudinal lateral costae. The denticles on the posterior blade are slightly reclined and show little deflection (divergence) from the axis. A large secondary denticle, almost equal to or larger in size than the main cusp projects from the region of the maximum aboral deflection of the posterior blade. Most of the denticles are laterally compressed in cross section. The size and number of denticles varies.

The other elements of this multielement subspecies are closer to homologous elements of *P. flexuosus flexuosus*. Their denticles do, however, appear to be finer, more compressed and more tightly packed than homologous elements of *P. flexuosus flexuosus*.

*Remarks:* The close relationship of *P. flexuosus flexuosus* and *P. flexuosus symmetricus* and their stratigraphic ranges suggests that *P. flexuosus flexuosus* was ancestral to *P. flexuosus symmetricus* (? by transformation in time). Support for this hypothesis comes from the occurrence of a collection of elements that are intermediate between these two forms, from a stratigraphic horizon that is probably near the boundary between the ranges of these two subspecies (P1205:367, referred to as *P. flexuosus* late form). Raring (1972), in an unpublished thesis, also noted that phragmodiform elements of *P. flexuosus* are more delicate and less sinuous in samples assigned to Fauna 6 than those belonging to Fauna 5.

Ethington and Schumacher (1969) have illustrated and described specimens from the Copenhagen Formation of Nevada as *Phragmodus undatus* Branson and Mehl (Pl. 67, fig. 15) and *Cyrtoniodus flexuosus* (Branson and Mehl) (Pl. 67, fig. 11) that are close to the phragmodiform and cyrtoniodiform elements of *P. flexuosus symmetricus*. Slightly higher up in Section A, elements of *P. flexuosus symmetricus* appear to undergo modification towards increased symmetry. This is referred to as the 'late form' and is illustrated through pictures (see Pl. 22, figs. 18-20 for the phragmodiform, cordylodiform and cyrtoniodiform elements).

*Occurrence:* Upper Chazyan collections from Sections A, H and P.

*Material:* Phragmodiform elements 43, cyrtoniodiform elements 71, cordylodiform elements 39, dichognathiform elements 14.

*Illustrated Material:* GSC50480, GSC50120, GSC50481, GSC50122, GSC50482, GSC50126, GSC50127

### Phragmodus inflexus Stauffer

(Pl. 22, figs. 16, 17)

Phragmodus inflexus (part) Stauffer, 1935 , p. 151, Pl. 11, figs. 9, 16, 20, 25, 26 (not figs. 15, 17, 19, 21, 22, 34); Fay, 1952, p. 146; Webers, 1966, pp. 40, 41, fig. 8; Pl. 8, figs. 1, 2, 4.

Dichognathus peculiaris Stauffer, 1935 , p. 141, Pl. 11, figs. 2, 4, 6, 11; Fay, 1952, p. 86.

Dichognathus typicus (part) Stauffer, 1935 , p. 141, Pl. 11, figs. 2, 3, 5, 8 (not fig. 10); Fay, 1952, p. 86; Andrews, 1967, p. 889, Pl. 115, fig. 12.

Phragmodus singularis Stauffer, 1935 , p. 151, Pl. 11, figs. 23, 24, 35, 36; Fay, 1952, p. 146.

Subcordylodus elongatus Stauffer, 1935 , p. 153, 154, Pl. 11, fig. 33.

Subcordylodus sinuatus Stauffer, 1935 , p. 154, Pl. 11, figs. 28, 37, 42, 45; Fay, 1952, p. 194.

Cyrtoniodus flexuosus (Branson and Mehl), Bergström and Sweet, 1966, pp. 324-327, Pl. 32, figs. 9-11 (synonymy through 1966); Andrews, 1967, p. 888, Pl. 113, fig. 14.

Phragmodus undatus Branson and Mehl, Andrews, 1967, p. 896, Pl. 114, fig. 10.

Remarks: Elements of this species are relatively sparse in these collections.

Occurrence: The species is identified only from Section P and possibly from Section E.

Material: 8 specimens

Illustrated

Material: GSC50154, GSC50155

## Phragmodus undatus Branson and Mehl

(not illustrated)

Phragmodus undatus Branson and Mehl, 1933, p. 115, Pl. 8, figs. 22-26; Bergström and Sweet, 1966, pp. 369-372, Pl. 28, figs. 13-20 (includes synonymy through 1966); Winder, 1966, Pl. 10, fig. 11; Sweet and Bergström, 1970, figs. 5A-D; Globensky and Jauffred, 1971, p. 57, Pl. 4, figs. 7-13; Sweet, Ethington and Barnes, 1971, Pl. 2, figs. 7-10; Uyeno, 1974, pp. 15, 16, Pl. 1, figs. 26-30; Barnes, 1977, p. 107, Pl. 4, figs. 2-5.

Dichognathus attenuata Branson and Mehl. Winder, 1966, Pl. 10, fig. 21.

Oistodus abundans Branson and Mehl. Winder, 1966, Pl. 9, fig. 16.

Remarks: All elements of this multielement taxon have been illustrated in Tipnis et al. (in press).

Occurrence: Elements of this species are abundant in collections from the Whittaker Formation at Section E, but also occur sporadically in several other collections from this Formation.

Material: Phragmodiform elements, over 1210; dichognathiform elements, over 700; oistodiform elements, about 100.

### Phragmodus n. sp. 1 s.f.

(Pl. 24, figs. 17, 18)

Description: A phragmodiform element with a moderately robust, rounded to subrounded, smooth to finely costate cusp with a reduced posterior process that bears very few denticles that show little deflection from the axial plane. One of these denticles is usually larger than the cusp. It follows immediately after the cusp or is separated from the cusp by a single small denticle. The posterior process is relatively wide and thick. It is deflected downwards but does not show much simuosity. The basal opening appears to be very shallow. A similar element may have been previously illustrated by Barnes (Barnes, 1974, Pl. 1, fig. 21).

Occurrence: Upper Esbataottine and Sunblood (?) formations at Sections H and B.

Material: 7 specimens

Illustrated Material: GSC50512, GSC50513

### *Phragmodus* n. sp. B

(Pl. 6, figs. 1-3)

Remarks: A multielement species of *Phragmodus* with a modified phragmodiform element that bears two processes; the main process is similar to that of the phragmodiform element of *P. flexuosus*, whereas the other process is drawn off laterally from the main cusp at an angle of about 60° to the main process in a periodontid (eoligonodinid) fashion. This lateral process may carry up to three (or more) denticles which are flexed sideways. The other elements making up the species are probably the cyrtoniodiform element (Pl. 6, fig. 3) and possibly a 'normal' phragmodiform element.

Occurrence: From the Road River Formation at Locality 5.

Material: Phragmodiform elements 4, eoligonodiniform elements 4, cyrtoniodiform elements 2.

Illustrated Material: GSC50905, GSC50239, GSC50240

## "Phragmodus" n. sp. A

(Pl. 20, figs. 9-16)

Diagnosis: A multielemental species of Phragmodus consisting of phragmodiform, cordylodiform, dichognathiform and cyrtoniodiform elements. The species appears to be hyaline and characterized by a robust cusp and tall discrete denticles.

Remarks: This apparatus contains elements that are similar to and homologous with the elements of Phragmodus flexuosus Moskalenko, but occurs earlier and is possibly hyaline in composition.

Description: The phragmodiform element consists of a thick broad cusp and a slightly arched to nearly straight posterior process. The large secondary denticle is equal in size to the cusp, and few additional denticles are present. The basal cavity is very narrow. The apparatus includes both cordylodiform elements and subcordylodiform elements. The former consists of elements with a robust subrounded cusp (costate to acostate) and an arched posterior process that bears several discrete denticles, usually leaning towards the posterior. The subcordylodiform element bears denticles on the posterior edge of the cusp that appear to be fused proximally but become separated distally. The basal opening is usually narrow.

Two types of cyrtoniodiform elements belong here. One has a dichognathid type outline. It is usually very robust with a large costate to acostate cusp, which is compressed, but not flat. The base is slightly offset to give a twisted appearance to the unit. The posterior process is short and bears up to 2 small compressed denticles. This element though not illustrated here is similar to the cordylodiform element of Eoneoprioniodus n. sp. A, except for the absence of an anterolateral process. The other cyrtoniodiform element is a compressed unit with a tall flat cusp and denticles. The posterior process bears up to 4 or 5 small subdiscrete, well compressed denticles. They are usually in the same plane. In some, the anterior margin is extended and carries 3-4 denticles. These may be referred to as the eoligonodiniform elements.

The dichognathiform elements are very similar to the dichognathiform element of P. flexuosus. They are usually adentate: however, a few show the presence of one posterior denticle.

Occurrence: Late Whiterockian collection from the Sunblood Formation.

Material: Phragmodiform elements 2, cordylodiform elements 42, cyrtoniodiform elements 27, dichognathiform elements 18.

Illustrated Material: GSC50445, GSC50106, GSC50112, GSC50446, GSC-50447, GSC50448, GSC50449, GSC50741.

### Genus Plectodina Stauffer, 1935

Type species: Plectodina aculeata (Stauffer), 1935

### Plectodina aculeata (Stauffer)

(Pl. 21, figs. 13-20; Pl. 23, figs. 8, 19)

Prioniodus aculeatus Stauffer, 1935, p. 126, Pl. 10, fig. 12.

Plectodina aculeata (Stauffer). Uyeno, 1974, p. 16, Pl. 2, figs. 1-16 (part) (includes synonymy to 1974); Barnes, 1977, p. 107, Pl. 4, figs. 19, 23.

Discussion: Barnes (1977) noted that the full morphological range of Plectodina aculeata (Stauffer) has yet to be determined, and pointed out that Uyeno (1974) illustrated a wide range of component elements that may belong to three or four species or subspecies of Plectodina. A large range of morphology is presently included in the apparatus of P. aculeata. One problem may be the difficulty in distinguishing some elements of P. aculeata from those of Phragmodus flexuosus Moskalenko and P. flexuosus symmetricus Tipnis, Chatterton and Ludvigsen (in press). This is especially true of the cordylodiform and dichognathiform elements. Both the latter taxa often co-occur with P. aculeata, which tends to magnify this problem. Towards the upper limit of the range of P. aculeata, several elements are closer to homologous elements of P. furcata (Hinde), and are likely to be mistaken for that taxon. This view is based on the observation that elements of *P. aculeata* probably underwent gradual morphologic changes through the Chazyan-Blackriveran-Rocklandian interval into the Kirkfieldian, wherein they "transformed" into *P. furcata*. It is not unusual to find such a change (see discussion for *Phragmodus flexuosus symmetricus*, this thesis) amongst some conodonts. As to why this happens (phyletic gradualism vs. punctuated equilibria - Elridge and Gould, 1972) was not determined in this study.

*Remarks*: *Plectodina aculeata* (Stauffer) and *Ozarkodina ? obliqua* (Stauffer) have the same stratigraphic range and geographic occurrence, the same size, colour and mode of denticulation. Therefore, *O. ? obliqua* has been included in the apparatus of *Plectodina aculeata* (Stauffer). Collections at hand contain over 300 elements assignable to *P. aculeata*. The skeletal apparatus includes cordylodiform, trichonodelliform, zygognathiform, ozarkodiniform, prioniodiniform, and dichognathiform elements. Sweet *et al*. (1971) suggest that *P. aculeata* characterizes Faunas 7 and 8, and that the common occurrence of this species and *Phragmodus inflexus* defines Fauna 7. From the collections at hand, the lower range limit of *P. aculeata* can be extended below the first occurrence of *Phragmodus inflexus* and into the range of *Phragmodus flexuosus*, a feature also noted by Raring (1972). Thus while *P. aculeata* is very abundant in the "zone" of *Phragmodus inflexus*, as noted earlier, it is known from slightly older strata.

Occurrence: *Plectodina aculeata* is represented in almost every sample of Chazyan, Blackriveran and Rocklandian age.

Material: Eologonodiniform and cordylodiform elements 321, trichonodelliform elements 121, zygognathiform elements 129, prioniodiniform elements 3, dichognathiform elements 82, ozarkodiniform elements 22, oistodiform elements 31.

Illustrated Material: GSC50464, GSC50465, GSC50466, GSC50467, GSC50468, GSC50469, GSC50470, GSC50471, GSC50486, GSC50487

## Plectodina furcata (Hinde)

(Pl. 26, figs. 2, 3, 5-8, 10, 12-14)

Prioniodus furcatus Hinde, 1879, p. 358, Pl. 15, fig. 13.

Plectodina furcata (Hinde), Sweet et al., 1975, p. 37, Pl. 2, figs. 1-7, 9-11, 14-17 (includes synonymy).

Remarks: A complete diagnosis, description and treatment of Plectodina furcata was recently attempted by Sweet et al. (1975). Sweet et al. recognized two subspecies of P. furcata, P. furcata tenuis and P. furcata inclinata, and suggested that these taxa may be allopatric races. Although elements corresponding to P. furcata furcata are relatively numerous, attempts to separate them into different elements of the two subspecies has not met with much success (I have few of the distinctive P elements). I have therefore confined myself to the species P. furcata (see discussion under genus Aphelognathus for possible confusion with Plectodina furcata).

Occurrence: Elements of P. furcata are present in almost every collection of post-Rocklandian age from the Mackenzie Platform. They are also found in some late Middle Ordovician - early Late Ordovician collections from the Road River Formation.

Material: P elements 21, $A_1$ elements 26, $A_2$ elements 18, $A_3$ elements 72, $O_1$ elements 27, N elements 42 (total count not determinable).

Illustrated Material: GSC50169, GSC50170, GSC50171, GSC50172, GSC50173, GSC50174, GSC50175, GSC50176, GSC50177, GSC50179

### Genus *Polycaulodus* Branson and Mehl s.f.

**Type species:** *Polycaulodus inclinatus* Branson and Mehl, 1933

### *Polycaulodus bidentatus* Branson and Mehl

(Pl. 25, figs. 10, 18)

*Polycaulodus bidentatus* Branson and Mehl, 1933, p. 106, Pl. 8, figs. 1-3; Branson and Mehl, 1943, pp. 382, 383, Pl. 64, figs. 15, 29; Branson, 1944, p. 82, Pl. 11, figs. 4-6; Sweet, 1955, p. 250, Pl. 28, fig. 5; Webers, 1966, p. 68, Pl. 6, fig. 10; Andrews, 1967, pp. 897, 898, Pl. 112, figs. 2, 8, 15 (additional synonymy till 1967); Moskalenko, 1970, p. 82, Pl. 11, fig. 1; Atkinson, 1971, Pl. 3, figs. 2, 3; Uyeno, 1974, Pl. 3, fig. 3.

**Occurrence:** Sporadically through the Chazyan and Lower Blackriveran collections from the Sunblood and Esbataottine Formations.

**Material:** 36 broken elements occurring together with elements of *Curtognathus typus*.

**Illustrated Material:** GSC50130, GSC50525

### Polycaulodus spp. s.f.

(Pl. 20, fig. 18)

Remarks: Several polycaulodiform elements occur in the Whiterockian collections. At this stratigraphic level, these elements are not accompanied by any of the trucherignathiform, cardiodelliform or curtognathiform elements. Their distribution, however, shows some coincidence with that of Evencodus. They are included separately here. The main difference from younger polycaulodiform elements lies in these elements being much stubbier, thicker and shorter.

Occurrence: In the Whiterockian collections of the Sunblood Formation.

Material: 9 specimens

Illustrated Material: GSC50452

## Genus Polyplacognathus Stauffer, 1935

Emend. Bergström and Sweet, 1966

Type species: Polyplacognathus ramosus Stauffer, 1935

Emended Diagnosis: Polyplacognathus is a multielement genus composed of two platform-like elements, one of which is a modified amorphognathus-type with a star-shaped oral view, while the other is a modified ambalodus-like element, Y-shaped, with three processes similar in appearance to those of the amorphognathus-like element (Bergström and Sweet, 1966).

### Polyplacognathus friendsvillensis Bergström

(Pl. 4, figs. 18, 19; Pl. 5, fig. 15)

Polyplacognathus friendsvillensis Bergström, 1971, pp. 142, 143, Pl. 1, figs. 3, 4.

Remarks: Both the ambalodiform and polyplacognathiform elements of P. friendsvillensis appear to undergo evolutionary changes that have been illustrated by Bergström (1973) and Bergström and Carnes (1976, fig. 2, p. 32). Compared to these evolutionary sequences, the two polyplacognathiform and ambalodiform elements collected from the study area appear closer to the forms illustrated by Bergström and Carnes, and certainly represent the early forms, as the anterior process of the element is both narrow and straight. This suggests a stratigraphic position either within the Eoplacognathus robustus Zone or at a level near the base of E. lindstroemi Zone.

Occurrence: Elements of this species were recovered from the Road River Formation at Locality 5. Stratigraphic distribution of this taxon has been discussed by Bergström (1971).

Material: Polyplacognathiform elements 5, ambalodiform elements 3.

Illustrated Material: GSC50224, GSC50226, GSC50904

## Polyplacognathus ramosus Stauffer

(Pl. 25, fig. 19)

Polyplacognathus ramosus Stauffer, 1935, p. 615, Pl. 75, figs. 23, 28-31, 37; Uyeno, 1974, p. 14, Pl. 1, figs. 1-4 (includes synonomy up to 1974); Barnes, 1977, p. 108, Pl. 4, figs. 14, 15.

Remarks: Only one polyplacognathiform element was recovered from the Sunblood Formation at Section P (P1730:527).

Occurrence and Material: See above.

Illustrated Material: GSC50157

## *Polyplacognathus* sp. ?

(Pl. 5, fig. 10)

**Remarks:** A poorly preserved single ambalodiform element somewhat similar to the ambalodiform element of *Polyplacognathus sweeti* Bergström, in the sense that it has a moderately lobate anterior platform with a poorly developed central row of denticles. The posterior extension, probably broken, is almost as wide as the anterior platform and also bears a row of denticles. These are, however, not centrally situated and make an angle of about 80° to the denticle row of the anterior platform. The third process is much narrower and shorter and has well developed denticles at about right angles to the anterior process. The basal cavity is deep and wide, a feature not characteristic of *Polyplacognathus*.

**Occurrence:** This specimen is present in the Road River Formation at Locality 5.

**Material:** 1 specimen

**Illustrated Material:** GSC50900

## Genus *Prioniodus* Pander

*Type species*: *Prioniodus elegans* Pander, 1856

*Remarks*: See Serpagli (1974) and Klapper *et al*. (1977) for the present interpretation of this multielement genus. Two prioniodiform elements recovered in this study are treated as form taxa. These include elements that have three processes, usually denticulate: the posterior, the anterior and the lateral.

### *Prioniodus crassulus* (Lindström), emend. Van Wamel, 1974

(Pl. 4, figs. 4, 5)

*Oepikodus crassulus* Lindström, 1955, p. 570, Pl. 5, fig. 36, not Pl. 5, fig. 37.

*Gothodus costulatus* Lindström, emend. Lindström, 1971, Pl. 1, figs. 4, 5.

?*Prioniodus acodiformis* Lindström, 1955, p. 591, Pl. 5, fig. 42.

*Prioniodus crassulus* (Lindström). Van Wamel, 1974, p. 83, Pl. 6, figs. 7-14.

Remarks: After Van Wamel's emendment, Landing (1976) and Klapper *et al*. (1977) have attempted to modify further the apparatus of *P*. *crassulus*. Landing included *Acodus* ? *gladiatus* Lindström *sensu* Serpagli, 1974, in the synonymy of *P*. *crassulus*, while Klapper *et al*. included additional elements and transferred the whole apparatus into *Baltoniodus*. Until further studies, these latter emendments are shelved. Only the oepikodiform element was recovered from the present collection.

Occurrence: From the Road River Formation at Section K (K2090:637, K2145:654).

Material: 5 specimens

Illustrated Material: GSC50220, GSC50221

### Prioniodus elegans ? Pander, emend. Van Wamel

(Pl. 2, figs. 22, 23)

Prioniodus elegans Pander, 1856, p. 29, Pl. 2, figs. 22, 23, Pl. 3, fig. 9; Lindström, 1955 , p. 589, Pl. 5, figs. 26-29, Fig. 5a; emend. Lindström, 1971, p. 51; emend. Van Wamel, 1974, p. 87, Pl. 6, figs. 1-6.

Belodus gracilis Pander, 1856, (pars), Pl. 3, fig. 8, not p. 30, Pl. 2, fig. 21.

Gothodus costulatus Lindström, 1955 , p. 569, Pl. 5, figs. 23-25.

Prioniodus carinatus Pander, 1856, Pl. 3, fig. 7, not p. 30, Pl. 2, fig. 25.

Falodus prodentatus (Graves and Ellison). Lindström, 1955 , p. 569, Pl. 5, figs. 21, 22, 30; not Oistodus prodentatus Graves and Ellison, 1941, p. 13, Pl. 2, figs. 16, 22, 23, 28.

Remarks: The apparatus of P. elegans, as put together by Van Wamel (1974), differs from that of Lindström (1971). For this study, Van Wamel's reconstruction is used because it is more consistent with Bergström's (1968) interpretation of this taxon which, for reasons noted by Sweet and Bergström (1972, p. 35), appears more plausible. Possibly two elements are present; one, the prioniodiniform element, which is similar to that illustrated and described by Van Wamel (op. cit.), and the other, a poorly preserved element, may be the gothodiform element of this species. The question mark at the end of the species refers to the obvious incompleteness and possible misidentification of this taxon.

Occurrence: In the Road River Formation at Section K (K2020:616).

Material: Gothodiform elements 3, prioniodiniform element 1

Illustrated Material: GSC50875, GSC50876

## Prioniodus sp. 1 s.f.

(Pl. 15, fig. 15)

Description: A prioniodiform element bearing several denticles along a long and almost straight posterior process, and a smaller number of denticles on a straight lateral process that makes a sharp angle with the anterior process. The anterior process is undenticulate; and is somewhat sinuous so that the aboral margin is folded sharply inwards between the anterior and lateral processes. The cusp is broken but appears to have been broad and somewhat compressed. The denticles are not fully developed. The upper surface of the element is smoother than those of other taxa from the same collection. The resemblance to a poorly denticulated specimen of Prioniodus navis Lindström is striking (see Lindström, 1955, Pl. V, fig. 33).

Occurrence: Basal part of the Sunblood Formation at Section H.

Material: 2 specimens

Illustrated Material: GSC50089

## Prioniodus sp. 2 s.f.

(Pl. 15, fig. 13)

Description: A prioniodiform element characterized by a general 'stubbiness' that includes both the cusp and the denticles. A prominent cellular microsculpture is present towards the basal part of the element.

The cusp is short, stubby and only slightly taller than adjacent denticles. Both posterior and lateral processes are moderately long and bear several denticles that possess a very low relief and merely protrude above the processes in broad, stublike fashion. The posterior denticles appear to be inclined away from the main cusp (?), while the lateral ones are inclined toward it. The anterior process is recurved away from the lateral process and bears two relatively large, almost complete denticles.

Occurrence: Low in the Sunblood Formation at Section E.

Material: 1 specimen

Illustrated Material: GSC50087

## Genus Proconodontus Miller, 1969

Type species: Proconodontus muelleri Miller, 1969

Remarks: Several specimens fit the general description of the genus: "large simple cones with deep and large basal cavity that may extend to the tip of cusp. Laterally compressed, symmetrical or asymmetrical. At least the anterior edge is sharp" (taken from Miller, 1969). In some, however, the basal cavity cannot be distinguished and the cusp cross section is the only basis for distinguishing species.

## Proconodontus muelleri muelleri Miller s.f.

(Pl. 1, figs. 9, 10)

Proconodontus muelleri muelleri Miller, 1969, p. 437, Pl. 66, figs. 30-40, text-fig. 5H; Miller and Melby, 1971, p. 123, Pl. 2, fig. 18; Müller, 1973, p. 42, Pl. 3, figs. 4a,b, 5a,b, 6-8, 10; Miller, 1976, p. 591, Pl. 1, figs. 4, 5.

Coelocerodontus burkei Druce and Jones, 1971, p. 61, Pl. 11, figs. 5?, 7, 11 (non 6, 12), text-fig. 22A (non E).

Coelocerodontus muelleri Jones, Shergold and Druce, 1971, pp. 18-19, text-fig. 6.

Remarks: Thin walled, with very large basal cavity extending to tip of unit. Carinae at convex and concave edges are not denticulated, although the sides of some specimens have undulated surfaces.

Occurrence: From Proconodontus Zone of the Rabbitkettle Formation.

Material: 21 specimens

Illustrated Material: GSC50856, GSC50857

### Proconodontus notchpeakensis Miller s.f.

(Pl. 1, fig. 8)

Oneotodus sp. indet. Müller, 1959, p. 458, Pl. 13, fig. 15.

Oneotodus nakamurai Nogami, 1967, pp. 216, 217, Pl. 1, figs. 5, 10, 11, text-figs. 3D,E (only); Druce and Jones, 1971, pp. 82, 83, 107, Pl. 10, figs. 1, 2, 5-7, text-fig. 26j (only).

Proconodontus notchpeakensis Miller, 1969, p. 438, Pl. 66, figs. 21-29, text-fig. 5G; Miller and Melby, 1971, p. 123, Pl. 2, figs. 19, 20; Müller, 1973, p. 43, Pl. 4, fig. 6.

Remarks: Only one specimen is confidently identified as this species, although several other proconodontids that resemble it but are too opaque to examine the depth of the basal cavity are also included in it.

Occurrence: In Proconodontus Zone of the Rabbitkettle Formation.

Material: 6 specimens

Illustrated Material: GSC50855

### Proconodontus rotundatus (Druce and Jones) s.f.

(Pl. 1, figs. 14, 21)

Coelocerodontus rotundatus Druce and Jones, 1971, p. 62, Pl. 9, figs. 10a-13b, text-figs. 22, 22d; Jones, 1971, p. 45, Pl. 1, figs. 1a-1c; Jones, Shergold and Druce, 1971, p. 18, text-fig. 6.

Proconodontus cf. rotundatus Müller, 1973, p. 43, Pl. 3, figs. 1a, 1b, 2a, 2b.

Prooneotodus rotundatus (Druce and Jones), Miller, 1976, p. 596, Pl. 1, figs. 24, 25.

Description: Cusp is reclined and thin-walled, with a deep basal cavity extending to the tip. Cross section of cusp nearly circular, slightly flaring near the base. The cusp is translucent.

Remarks: These specimens are nearly circular in cross section and lack ornamentation, and may even fall within the range of variation of Prooneotodus Müller and Nogami (Miller, 1976). Müller (1973), however, prefers to include this species within Proconodontus.

Occurrence: Middle part of the Rabbitkettle Formation.

Material: 8 specimens

Illustrated Material: GSC50013, GSC50014

Proconodontus cf. P. muelleri Miller s.f.

(Pl. 1, figs. 12, 13)

Remarks: Several elements included here appear to be variants of P. muelleri. They generally have a strong carina (P. carinatus type), are somewhat twisted towards the base, which is either extended or expanded; and possess a much wider cusp than P. muelleri. Similar forms have previously been referred to P. muelleri (see Miller and Melby, Pl. 2, fig. 19). These occur stratigraphically higher than P. muelleri s.s.

Occurrence: Sporadic through the upper Rabbitkettle Formation.

Material: 4 specimens

Illustrated Material: GSC50002, GSC50859

### *Proconodontus* ? *primitivus* (Müller) *sensu* Druce and Jones s.f.

(Pl. 1, fig. 16)

aff. *Coelocerodontus primitivus* (Müller), Druce and Jones, 1971, pp. 62, 63, Pl. 9, figs. 5a-6c, 8a-c, text-fig. 22b.

*Remarks*: These elements are similar to *P*. *rotundatus* except they have a more expanded basal outline and shorter, broader cusps. Similar elements were identified as *Coelocerodontus primitivus* (Müller) by Druce and Jones (1971). One of the specimens (Pl. 1, fig. 16) shows a white cusp.

*Occurrence*: Sample K525:160 and sample K880:268 of the Rabbitkettle Formation.

*Material*: 2 specimens

*Illustrated Material*: GSC50861

## Proconodontus ? sp. s.f.

(Pl. 1, figs. 3-5)

Remarks: Several elements having thin-walled simple cones with deep basal cavities and unornamented convex lateral sides are included here. The anterior and posterior edges are rounded on most specimens, but on some the edges are sharper but lack keels. The cross section of the cusp is oval to subrounded; and all specimens are light grey in colour.

Some of these specimens may be ancestral to forms similar to Proconodontus muelleri Miller, while some fit the characteristics of Proconodontus rotundatus, as defined by Druce and Jones (1971).

Occurrence: Occur in the lower part of the Proconodontus Zone (K525:160).

Material: 8 specimens

Illustrated Material: GSC50850, GSC50851, GSC50852

### Genus Prooneotodus Müller and Nogami, 1971

Type species: Oneotodus gallatini Müller, 1959

Remarks: Cambrian specimens have a deep basal cavity, and other distinctive histologic characteristics that separate them from Oneotodus, as described by Müller and Nogami (1971). In Bengston's (1976) terminology it would be placed among the paraconodonts, although, as noted by Landing (1977), some may even belong to the protoconodonts.

### Prooneotodus tenuis (Müller) s.f.

(Pl. 1, fig. 2)

Oneotodus tenuis Müller, 1959, p. 457, Pl. 13, figs. 11, 13, 14, 20; Nogami, 1966, p. 356, Pl. 9, figs. 11, 12; Clark and Robison, 1969, p. 1045, text-fig. 1a; Druce and Jones, 1971, p. 83; Müller, 1971, p. 8, Pl. 1, figs. 1, 4-6; Jones, Shergold and Druce, 1971, p. 18, text-fig. 6.

?Oneotodus tenuis Müller. Miller, 1969, p. 436.

Prooneotodus tenuis (Müller). Müller, 1973, p. 45, Pl. 1, figs. 1-2a, 3b.

Prooneotodus tenuis Miller, 1976, p. 596, Pl. 1, figs. 20-23.

Remarks: Cross section of cusp varies from circular near the base to slightly oval towards the top. The surface appears etched, and longitudinal striations were not seen.

Landing (1977) has noted the problem of *Prooneotodus tenuis sensu* Landing as related to *P. tenuis* s.s., namely that the latter is a paraconodont while the former is a protoconodont *sensu* Bengston (1976). By original definition, *P. tenuis* should be regarded as a paraconodont. The distinction between the two being primarily ultrastructural, it is not possible to separate them in this study. However, *P. tenuis sensu* Landing is not included in the synonymy.

*Occurrence*: Low in the Rabbitkettle Formation, K525:160.

*Material*: 1 specimen

*Illustrated Material*: GSC50005

## Genus Protopanderodus Lindström, 1971

Type species: Acontiodus rectus Lindström, 1955

Remarks: This genus was erected by Lindström (1971, p. 50) to include panderodids with a short base, long cusp and a cross section that varies from subcircular, through lanceolate and comma-shaped to Acontiodus-like.

The apparatus includes symmetrical and asymmetrical elements arranged in a transition series (especially drepanodiforms, scandodiforms, acontiodiforms), and usually the elements tend to develop a few costae. The nomenclature of protopanderodids has become somewhat problematic because of a very open definition.

In the case of Protopanderodus cooperi (Sweet and Bergström), both Barnes and Poplawski (1973) and Landing (1976), included elements of Scolopodus varicostatus Sweet and Bergström, Scandodus pipa Lindström and Scandodus rectus Lindström amongst others in its synonymy. S. varicostatus is a well-known taxon because of its significance to multielement taxonomy (see Sweet and Bergström, 1962). This familiar name has now become suppressed. Also note that Scandodus pipa is an element of Drepanodus arcuatus, while Scandodus rectus belongs to Protopanderodus rectus sensu Van Wamel. Another problem with this loose definition is the inclusion of several elements that clearly do not belong to this genus (see discussion of Barnes and Poplawski, 1973).

### *Protopanderodus cooperi* (Sweet and Bergström)

(Pl. 7, figs. 1-4, 15)

*Acontiodus cooperi* Sweet and Bergström, 1962, p. 1221, Pl. 168, figs. 2, 3, text-fig. 1G; Hamar, 1964, p. 257; Bradshaw, 1969, p. 1147, Pl. 131, fig. 5.

*Scolopodus varicostatus* Sweet and Bergström, 1962, Pl. 168, figs. 4-9, text-figs. 1A, C, K; Hamar, 1964, p. 108, Pl. 1, figs. 1, 2, text-fig. 4 (7a,b); Lindström, 1964, p. 108; Bradshaw, 1969, p. 1163, Pl. 132, fig. 10, Pl. 134, figs. 12, 13; Bergström, 1971, text-figs. 4, 5, 10.

?*Drepanodus homocurvatus* Lindström. Hamar, 1964, p. 264, Pl. 2, figs. 3, 4, text-fig. 6 (3b).

*Protopanderodus cooperi* (Sweet and Bergström). Barnes and Poplawski, 1973, p. 782, Pl. 3, figs. 1, 4, 5, Pl. 4, figs. 8, 15 (in part); Landing, 1976, pp. 638, 639, Pl. 4, figs. 6, 7 (in part).

*Protopanderodus reclinatus* (Lindström). Barnes and Poplawski, 1973, p. 782, Pl. 3, fig. 2.

aff *Scandodus* sp. Sweet and Bergström, 1962, p. 1264, Pl. 168, figs. 13, 16.

*Remarks*: Barnes and Poplawski (1973) included *Scandodus rectus* in synonymy with *P. cooperi*; while Landing (1976) incorporated *Scandodus pipa*. For reasons noted earlier (discussion on *Protopanderodus*), I have not included them in synonymy.

Occurrence: Elements of P. cooperi (especially those belonging to the form taxon Scolopodus varicostatus) dominate the Road River Formation collection from Section K (K2325: 724). They show the same type of symmetry transition noted for the Pratt Ferry material by Sweet and Bergström (1962). A few specimens are also present at the Locality 5 collection from the Road River Formation.

Material: Over 130 specimens, often not complete; therefore real count is difficult.

Illustrated Material: GSC50916, GSC50200, GSC50917, GSC50201, GSC50244

### *Protopanderodus gradatus* Serpagli

(Pl. 17, figs. 15, 16)

*Cordylodus simplex* Branson and Mehl, Graves and Ellison, 1941, p. 3, Pl. 1, figs. 4 (?), 11.

?*Paltodus variabilis* Furnish, Higgins, 1967, text-fig. 2 (7); Lee, 1970, p. 331, Pl. 7, fig. 31.

*Protopanderodus gradatus* Serpagli, 1974, pp. 75-77, Pl. 15, figs. 5a-8b; Pl. 26, figs. 11-15.

Remarks: Elements of this taxon show an uncanny resemblance to *P. rectus sulcatus* (Lindström). The only difference, as far as I can see, is that *P. gradatus* usually consists of cones that are less elongated, somewhat broader and probably thicker.

Occurrence: Basal Sunblood Formation at Section H and upper Broken Skull Formation.

Material: 18 specimens

Illustrated Material: GSC50394, GSC50395

## Protopanderodus insculptus (Branson and Mehl)

(Pl. 7, fig. 14)

Phragmodus insculptus Branson and Mehl, 1933, p. 124, Pl. 10, figs. 32-34.

Scolopodus insculptus (Branson and Mehl). Bergström and Sweet, 1966, pp. 398-400, Pl. 34, figs. 26, 27, text-fig. 13B (includes synonymy through 1966); Winder, 1966, p. 60, Pl. 9, fig. 21, text-figs. 3-21; Serpagli, 1967, pp. 97-99, Pl. 28, figs. 1a-6b; Barnes, 1974, Pl. 1, fig. 19.

Protopanderodus insculptus (Branson and Mehl). Sweet, Thompson and Satterfield, 1975, Pl. 1, figs. 19, 20; Barnes, 1977, p. 108, Pl. 3, fig. 3.

Remarks: Barnes (1977) has recently pointed out the possible paroistodid affinities of this taxon. The species has evolved from Scolopodus varicostatus (Bergström, 1971; and Barnes, 1977).

Occurrence: Rare in the Road River Formation at Locality 5 and Locality 2.

Material: 7 specimens

Illustrated Material: GSC50943

Protopanderodus rectus (Lindström), emend. Van Wamel, 1974

(Pl. 2, fig. 14)

Acontiodus rectus Lindström, 1955, p. 549, Pl. 2, figs. 7-11; fig. 2k-m, fig. 3B.

Protopanderodus rectus (Lindström), emend. Lindström, 1971, p. 50; Van Wamel, 1974, p. 93, Pl. 4, figs. 7-10.

Acontiodus rectus sulcatus Lindström, 1955, p. 550, Pl. 2, figs. 12-13; fig. 3D.

Scandodus rectus Lindström, 1955, p. 593, Pl. 4, figs. 21-25; fig. 3K.

Remarks: Van Wamel (1974) emended the apparatus of P. arcuatus (Lindström) to include Acontiodus rectus sulcatus s.f. Lindström. This emended diagnosis of P. rectus is accepted here.

Occurrence: Low in the Road River Formation at Section K.

Material: 6 specimens

Illustrated Material: GSC50022

## Protopanderodus cf. P. leonardii Serpagli

(Pl. 17, figs. 3-5)

Scandodus ? n. sp., Ethington and Clark, 1965, p. 119, Pl. 1, fig. 6.

Protopanderodus leonardii Serpagli, pp. 77-79, Pl. 16, figs. 1a-4c; Pl. 27, figs. 12-16; text-fig. 18.

Remarks: Several simple cones conform to the definition of P. leonardii. However, they do not seem to be basally extended to the amount noted in the Argentinean collections.

Occurrence: From the middle and upper part of the Broken Skull Formation.

Material: 22 specimens

Illustrated Material: GSC50383, GSC50384, GSC50385

### Protopanderodus sp. aff. P. asymmetricus Barnes and Poplawski

(Pl. 9, figs. 15, 19, 20)

aff. Protopanderodus asymmetricus Barnes and Poplawski, 1973, pp. 781, 782, Pl. 1, figs. 12, 12a, 14, 16, text-fig. 2A.

Remarks: Specimens from the present collection differ from P. asymmetricus only with respect to smaller size, the location of the posterior groove, which appears to be more centrally situated, and the more rounded basal outline.

Occurrence: Lower part of the Broken Skull Formation.

Material: 14 specimens

Illustrated Material: GSC50271, GSC50272, GSC50273

### *Protopanderodus* ? sp. aff. *P.* ? *tricarinatus* Barnes and Poplawski

(Pl. 11, figs. 18, 19)

aff. *Protopanderodus* ? *tricarinatus* Barnes and Poplawski, 1973, p. 784, Pl. 1, fig. 5, text-fig. 2B.

*Remarks*: Specimens from the present collection differ from *P.* ? *tricarinatus* primarily in the cross section of the lower part of the cusp and the shape of the basal opening. In *P.* ? *tricarinatus* the posterior ridge becomes sharp basally while the shape of the basal outline is triangular. In the present species, the posterior ridge retains the same sharpness throughout the length of the unit, while the basal outline is subrounded to oval, and narrower than the width of the cusp at midpoint.

*Occurrence*: Lower part of the Broken Skull Formation.

*Material*: 20 specimens

*Illustrated Material*: GSC50037, GSC50036

### Genus Pteracontiodus Harris and Harris

Type species: Pteracontiodus aquilatus Harris and Harris, 1965

Remarks: McHargue (1974) suggested that this genus be included in Multioistodus. The multioistodid affinity of this taxon is quite evident. However, the collections at hand are too meagre to determine its placement into a new multielemental species, and the genus is treated under form taxonomy.

### Pteracontiodus exilis Harris and Harris s.f.

(Pl. 19, fig. 20)

Pteracontiodus exilis Harris and Harris, 1965, p. 42, Pl. 1, figs. 4a-c.

Remarks: The element at hand resembles Pteracontiodus exilis in almost every way, except for the greater curvature associated with the oral margins of the two lateral alars. The angle between the lateral edges of the cusp and the oral margins of the alars is, as a consequence, nearly 90° or less. In P. exilis, this angle is greater than 90°.

Occurrence: Whiterockian collection that includes Multioistodus fauna.

Material: 2 specimens

Illustrated Material: GSC50438

## Genus "Ptiloconus" Sweet, 1955 s.f.

Type species: Pteroconus gracilis Branson and Mehl, 1933

### "Ptiloconus(?)" strachognathoides Moskalenko

(Pl. 24, figs. 12, 16)

Ptiloconus (?) strachognathoides Moskalenko, 1973, p. 76, Pl. XVIII, figs. 18, 19, 20.

Remarks: As noted earlier, this genus is considered to be synonymous with Erismodus/Microcoelodus. Moskalenko (1972) recently described several multielemental taxa belonging to this genus. In a later study, she described a new species, Ptiloconus (?) strachognathoides, whose basic plan and morphology appear to be quite different from those of Ptiloconus, Erismodus and Microcoelodus. These elements probably belong to some new genus. More probably it appears that elements of P. ?strachognathoides, as illustrated by Moskalenko, as well as those found in my collection, represent a transitional series consisting of elements similar to those noted for the Cordylodus species, C. spinatus, by Lindström (1964).

The cordylodiform element usually consists of a large cusp and a secondary denticle that occupies a position immediately in front of the main cusp or follows one or two short denticles. Denticles occurring distally are usually smaller and inclined away from the cusp.

One variant of this element includes forms with anterior denticles (Pl. 24, fig. 16). The basal opening varies from small and pit-like to moderately deep. The sinuosity of the posterior process is not noticeable. In this respect, it differs from analogous elements of *Phragmodus flexuosus*.

*Occurrence*: Several lower Chazy collections from Section P.

*Material*: 15 specimens

*Illustrated Material*: GSC50510, GSC50511

## Genus Pygodus Lamont and Lindström, emend. Bergström, 1971

Type species: Pygodus anserinus Lamont and Lindström, 1957

### Pygodus serrus (Hadding)

(Pl. 4, figs. 17, 20, 21)

Arabellites serra Hadding, 1913, p. 33, Pl. 1, figs. 12, 13.

"Arabellites" serra Hadding, Lindström, 1960, p. 91, fig. 7:6.

Periodon serra (Hadding), Lindström, 1955b, pp. 110-111, Pl. 22, figs. 17, 20-25.

Pygodus n. sp. 2 Lindström, 1960, p. 91, fig. 7-1.

Pygodus anserinus Lamont and Lindström, Wolska, 1961, p. 357, figs. 4, 5.

?Pygodus trimontis Hamar, 1966, p. 70, Pl. 7, figs. 12, 16, 17.

Pygodus serrus (Hadding) Bergström, 1971, p. 149, Pl. 2, figs. 22, 23.

Occurrence: Road River Formation at Locality 5.

Material: Pygodiform elements 48, haddingodiform elements 62.

Illustrated Material: GSC50229, GSC50230, GSC50227

### Pygodus n. sp. 1 Uyeno and Barnes s.f.

(Pl. 5, fig. 9)

Pygodus n. sp. 1 Uyeno and Barnes, 1970, pp. 114, 115, Pl. 24, figs. 1,2.

Remarks: Uyeno and Barnes (1970) reported a species of Pygodus that possessed only two rows of nodes. The present occurrence of this species from the Road River Formation is important in two ways:

1) it corroborates the ideas of Uyeno and Barnes on the position of this Pygodus species with respect to that of P. serrus in both the stratigraphic and evolutionary senses [P. serrus, bearing three rows of nodes, is stratigraphically younger than the present taxon].

2) it reaffirms the possibility that no haddingodiform elements occur with this Pygodus species, a fact also noted by Uyeno and Barnes (op. cit.).

Occurrence: From the Road River Formation at Section K (K2375:724).

Material: 1 specimen

Illustrated Material: GSC50299

## Pygodus sp.

(Pl. 8, fig. 1)

Diagnosis: An unusual pygodid with four rows of denticles (nodes), three of which radiate downwards from a central point at the apex of the unit, whereas the fourth row appears to biturcate downwards from the upper half of one of the three. The basal outline is pentagonal and the entire unit is very hollow and thin sheathed.

Description: In plan view the unit has downwardly directed rows of denticles (nodes), two of which make an inverted V shape at the apical end while the third row diverges from the apex at a large angle (greater than 120°). Joining this latter row, somewhere near the midpoint, is another short row that makes an inverted V near the position of meeting. The space between the margins is occupied by a very thin sheath that shows transverse bands between adjacent margins. All four faces are concave inwards. The shape of the basal opening is pentagonal with the aboral margin between the two most distinct rows extending frontwards into a V. The entire unit is very hollow. The basal sheath is quite similar to that of Pygodus ? sp., elements of New Genus New Species C and those of Stolodus sp. aff. S. stola (Lindström).

Remarks: The presence of Pygodus at this level, namely in Late Canadian rocks, is quite unusual. It is possible that the present Pygodus lineage may be quite different from the well-known pygodids of the Middle Ordovician.

Occurrence: Low in the Broken Skull Formation.

Material: 1 specimen

Illustrated Material: GSC50045

## Pygodus ? sp. s.f.

(Pl. 8, fig. 2)

Description: A pygodid with triangular outline with all three margins outwardly bowed so as to impart a twisted appearance to the unit. The entire unit is hollow.

In plan view the unit appears as a twisted pyramid with three edges projecting downwards from a central point. The edges are sharply angular near the tip and appear to flare outwards towards the lower third of the unit. In side view, the three edges (rows) bear several nodes that continue along their entire length. The faces of this unit are extremely thin sheathed, concave and possess narrow and continuous transverse ridges broken up by longitudinal discontinuous low ridges. The aboral surface is broadly excavated and very deep. The cusp is not well defined, and may be broken at the tip.

The similarity to Pygodus is obvious. It also resembles Nericodus Lindström and New Genus New Species 2 of this study.

Occurrence: Lower part of the Broken Skull Formation at Section P.

Material: 1 specimen

Illustrated Material: GSC50049

## Genus Reutterodus Serpagli, 1974

Type species: Reutterodus andinus Serpagli

Diagnosis: Reutterodus includes multielement conodonts with a skeletal apparatus composed of elements of three morphologic types which are cone-like unibranched and bibranched, respectively (Serpagli, 1974). The cone-like elements are formed by a short base and a short cusp bearing a keel-like costa laterally.

### Reutterodus andinus Serpagli

(Pl. 16, figs. 7, 8, 12)

?Drepanodus arcuatus Branson and Mehl, Graves and Ellison, 1941, pp. 3, 7, Pl. 1, figs. 1, 23 (?), not 7.

Reutterodus andinus Serpagli, 1974, pp. 79-81, Pl. 17, figs. 9a-d; Pl. 28, figs. 1-9b; text-figs. 19, 20.

Remarks: The cone-like elements of this species are present in the upper Broken Skull and lower Sunblood Formation. Despite the absence of both unibranched and bibranched elements, the close conformity of the cone-like elements in my collection with those described by Serpagli (1974) allows me to identify this species with R. andinus Serpagli. One of the specimens (Pl. 16, fig. 12) shows signs of incipient denticulation on one side (unibranched?). This comes from a younger collection than those without traces of denticles (G1235:386).

Occurrence: As noted above.

Material: 7 specimens

Illustrated Material: GSC50374, GSC50375, GSC50377

## Genus Rhipidognathus Branson, Mehl and Branson, 1951

Remarks: Rhipidognathus includes elements that have a shallow basal cavity and show a symmetry transition of the trichonodelliform, zygognathiform and cordylodiform type. The elements are well denticulated, compressed and usually hyaline.

## Rhiphidognathus ? n. sp. A

(Pl. 23, figs. 20, 21, 22)

Diagnosis: A multielemental species consisting of a reduced prioniodiform apparatus showing only the trichonodelliform-zygognathiform-cordylodiform transitional series. All elements have tightly packed denticles, with the median denticle usually broader and taller than the adjacent ones. A weak to prominent ledge-like structure marks the bases of the denticles. This ledge-like structure parallels the lower margin, and in some instances is also present along the axial regions of the median cusp.

Description: Trichonodelliform element: This element is characterized by a broad cusp that is highly compressed and taller than adjacent denticles. The latter are very closely packed together both apically and basally. Their inclination from the main cusp appears to increase distally. The basal opening apparently is restricted to the cusp. A conspicuous ledge is present beneath the denticles.

Zygognathiform element: This element is similar to the trichonodelliform element except that the cusp shows a prominent ledge-like structure along its axis and the basal opening extends underneath the denticles. This latter feature may in fact be present in the trichonodelliform elements (because of the damaged underside I have not been able to note it in this study).

Cordylodiform element: This element has an eologinodiniform outline with a long posterior process that bears six denticles and a short lateral process with up to three denticles. Along the posterior process, the second denticles appear to be wider than the apical denticle (cusp?), with the ledge being displayed very prominently.

Remarks: The usually accepted lower age limit of this genus is Middle Ordovician (Bergström and Sweet, 1966), and there has been no published account to date of its occurrence in rocks as old as Chazyan. This report, therefore, I believe, is the first to document the occurrence of this genus in lower Middle Ordovician rocks.

Occurrence: From Lower Chazy collections at Section B (B1005:306 and B1110:355).

Material: Trichonodelliform elements 3, zygognathiform elements 3, cordylodiform elements 2.

Illustrated Material: GSC50494, GSC50495, GSC50496

## Genus Rhodesognathus Bergström and Sweet, 1966

Type species: Ambalodus elegans Rhodes, 1953

Original Diagnosis: A multielement conodont genus composed of paired ambalodus-like conodont elements (Bergström and Sweet, 1966).

Remarks: Klapper et al. (1977) have revised the original diagnosis to include ambalodiform and amorphognathiform elements, the latter characterized by an inner lateral flare on the posterior process. The angle between the posterior and anterior process is generally small (90°-130°). Elements from one collection of the Road River Formation have been questionably included in this genus.

### Rhodesognathus n. sp. A ?

(Pl. 5, figs. 3, 6)

Remarks: The amorphognathiform element has a moderately pronounced cusp, from which three processes diverge. The anterior process consists of a narrow platform bearing up to five poorly-developed denticles arranged perpendicular to the platform surface. The process is directed downwards at an angle of about 25°-30° to the horizontal.

The lateral process, though broken, appears to be wider than the anterior process and also bears a few poorly-developed denticles. This process, also, is directed downwards. The posterior process is elongated as well as expanded toward the central region and bears an inner lateral flare. The row of denticles is asymmetrically situated over the platform and is made up of several low nodes.

The ambalodiform element included here has a poorly-developed cusp but very prominently diverging processes that are made up of narrow platforms. The denticles on all the three processes are well developed. The lateral process appears to lie at 90° to the plane that contains both the anterior and posterior processes. I have not seen them illustrated anywhere and they are probably new.

Occurrence: Road River Formation at Section K (K2375:724).

Material: Amorphognathiform elements 3, ambalodiform elements 3.

Illustrated Material: GSC50195, GSC50898

## Genus Scandodus Lindström, 1955

Type species: Scandodus furnishi Lindström, 1955

Definition: According to Lindström's redefinition (1971, p. 39) 'Scandodus includes hyaline, mainly drepanodiform elements with symmetry transition; they have not much white matter in the cusps except for the growth axis; the base is not much wider than the cusp and has a sharply conical basal cavity that in some elements opens to one side; the cusp has at least one shart edge.'

Remarks: Van Wamel (1974) introduced a new multielement taxon, Drepanoistodus conulatus, that includes S. furnishi as one of its components. Moreover, his genus Triangulodus possibly includes elements normally considered as belonging to Scandodus sensu Lindström. This is yet an unresolved problem.

### *Scandodus* sp. aff. *S. flexuosus* Barnes and Poplawski

(Pl. 9, figs. 5, 6)

aff. *Scandodus flexuosus* Barnes and Poplawski, 1973, pp. 785, 786, Pl. 2, figs. 1-4, text-fig. 2L.

*Discussion*: Most specimens of this form genus in my collections resemble the taxon, *S. flexuosus* Barnes and Poplawski, except that they have a more symmetrically erect basal portion than those from the Mystic Formation (Barnes and Poplawski, 1973). This difference may be due to the fact that the former are slightly older.

*Occurrence*: Lower and lower middle part of the Broken Skull Formation.

*Material*: 32 specimens

*Illustrated Material*: GSC50262, GSC50263

### Scandodus sp. s.f.

(Pl. 3, fig. 8)

Description: A scandodid with a cusp moderately long, recurved and twisted distally. The basal opening is circular in outline. The anterior and posterior margins are strongly keeled. The anterior keel, however, becomes less sharp from the point of greatest curvature to the base. Below this point of inflexion, the cusp is almost erect. The base is merely a continuation of the cusp. The basal opening is well rounded but filled so that the basal cavity cannot be seen. The element appears to be either broken or deformed basally.

Remarks: This specimen, except for the generally robust size and rounded basal opening, is quite similar to Scandodus flexuosus Barnes and Poplawski.

Occurrence: From the Road River Formation at Section K (K2375:724).

Material: 1 specimen

Illustrated Material: GSC50883

## Genus *Scolopodus* Pander, emend. Van Wamel, 1974

Type species: *Scolopodus sublaevis* Pander, 1856

Synonyms: *Scolopodus* Pander, 1856, p. 25.
*Scolopodus* Pander, emend. Lindström, 1955a, p. 594.
*Scolopodus* Pander, emend. Lindström, 1971, p. 40.

Remarks: *Scolopodus*, as emended by Van Wamel (1974), includes both symmetrical and asymmetrical elements, usually with a rounded cross-section. A posterior and/or anterior keel may be present. The sides of the elements are finely costate and the base not greatly expanded. Hyaline as well as non-hyaline conodonts may belong to this genus. As emended by Van Wamel, some of the protopanderodids described by Barnes and Poplawski (1973), such as *P. asymmetricus* and *P.* ? *tricarinatus*, may belong here.

## Scolopodus gracilis Ethington and Clark

(Pl. 11, figs. 14, 15)

?Drepanodus striatus Graves and Ellison, 1941, p. 11, Pl. 1, figs. 3, 12.

Scolopodus gracilis Ethington and Clark, 1964, p. 699, Pl. 115, figs. 2-4, 8, 9; Barnes and Poplawski, 1973, Pl. 3, figs. 6, 6a, 7, 7a, 8, 8a, text-figs. 2G, H (includes synonymy to 1973); Barnes, 1974, Pl. 1, fig. 2; Barnes and Slack, 1975, fig. 3A; Barnes, in Workum et al., 1976, p. 176, Pl. 4, fig. 6; Barnes, 1977, p. 103, Pl. 1, figs. 14, 15.

Remarks: Barnes and Poplawski noted that there are specimens that may be intermediate between the two species, Scolopodus gracilis and Scolopodus triangularis. Their synonymy also includes Scolopodus filosus Ethington and Clark sensu Mound, 1965, and ?Scolopodus cf. S. quadraplicatus Branson and Mehl sensu Bradshaw, 1969.

Occurrence: Several specimens of this species are present in the lower and the lower Middle part of the Broken Skull Formation.

Material: 24 specimens

Illustrated Material: GSC50307, GSC50035

### Scolopodus rex Lindström sensu Serpagli, 1974

(Pl. 9, figs. 16-18)

Scolopodus rex Lindström, 1955 , p. 595, Pl. 3, fig. 32; Lindström, 1957, tab. 1; Lindström, 1960, fig. 2 (8); Viira, 1966, tab. 1; Viira, 1967, fig. 1 (6), tab. 1; Lee, 1970, p. 334, Pl. 8, figs. 8, 9; Bednarczyk, 1971, p. 174; Bergström, Epstein and Epstein, 1972, p. 38, text-fig. 1b; ?Ethington, 1972, p. 22, Pl. 1, fig. 17; Serpagli, 1974, pp. 86, 87, Pl. 17, figs. 1a-3b; Pl. 28, fig. 10. Van Wamel, 1974, p. 94, Pl. 5, fig. 18; Landing, 1976, p. 640, Pl. 4, fig. 14.

Scolopodus cornutiformis Branson and Mehl, Ethington and Clark, 1965, p. 200, Pl. 1, figs. 12, 10 (?); ?Ethington and Clark, 1972, pp. 73, 74, Pl. 2, figs. 21, 22.

Remarks: Serpagli (1974) has discussed some of the problems associated with Scolopodus rex and Scolopodus cornutiformis Branson and Mehl. These two taxa have often been confused with one another. I believe that the present species belongs to S. rex Lindström, as interpreted by Serpagli (1974).

Occurrence: Sporadic to common in the lower and middle parts of the Broken Skull Formation.

Material: 46 specimens

Illustrated Material: GSC50046, GSC50047, GSC50270

## Scolopodus sp. aff. S. quadraplicatus Branson and Mehl

(Pl. 17, figs. 1, 2)

aff. Scolopodus quadraplicatus Branson and Mehl, 1933, p. 63, Pl. 4, figs. 14, 15; Barnes and Tuke, 1970, p. 93, Pl. 18, figs. 13, 14, 17; text-fig. 6F (includes synonymy through 1968); Moskalenko, 1967, pp. 114, 115, Pl. 25, figs. 3-5, text-fig. 16; ?Druce and Jones, 1971, pp. 93-94, Pl. 18, figs. 6a-7c, text-fig. 30f; ?Jones, 1971, p. 65, Pl. 6, figs. 6a-c; Barnes and Poplawski, 1973, p. 787, Pl. 1, fig. 11.

Remarks: The specimens of this taxon appear to be slightly more slender and have a less expanded base than the specimen illustrated by Barnes and Poplawski (1973). However, the other described features appear to be identical. Conodonts with tall, uni- or bi-costate, bilaterally symmetrical cusps, and a small base with a rounded aboral outline, dominate several Canadian collections from widely separated areas. This has resulted in considerable difficulty in recognizing this species. To some extent similar scolopodids, such as S. asymmetricus Druce and Jones, S. triplicatus Ethington and Clark, and S. variabilis Ethington and Clark, may fall with the range of variation that some workers would ascribe to S. quadriplicatus, (with slightly different placement of the lateral costae;

and a symmetry transition consisting of symmetric to asymmetric element). A definitive synonymy, therefore, is not possible, and the synonymy noted above is certainly incomplete. However, I have treated the taxon in a multielemental sense for reasons noted above. This shares the view of Barnes *et al*. (1977), wherein they include *Scolopodus* as their Type I simple cone apparatus.

**Occurrence**: Sporadic through the Broken Skull Formation.

**Material**: 15 specimens

**Repository**: GSC50381, GSC50382

## "Scolopodus" ? sp. s.f.

(Pl. 16, fig. 13)

Description: A short, stubby scolopodid with a wide, high base and a short, recurved cusp. The inner side of the cusp, with an extremely deep groove parallel and close to the posterior edge. The cusp is multicostate laterally, with the smaller lower costae disappearing distally. The anterior side is generally smooth.

The element is slightly asymmetrical, with the base twisted, so that the basal flare opens postero-laterally. The inner side of the cusp with an extremely deep groove parallel to and near the posterior edge. The anterior side of the cusp is rounded and smooth, with lateral faces that are multicostate basally, and with many of the smaller, lower costae disappearing apically; near the apex only three coarse costae are present. The anterior half of the upper side of the cusp is gently convex, becoming almost straight towards the base. The posterior margin forms a smooth curve with the upper margin of the base. The anterior upper margin is sharply rounded, while the antero-basal margin is broadly rounded in plan view. The basal cavity is relatively shallow and conical in shape.

Remarks: The elements are hyaline. Their unique shape does not fit them into Scolopodus s.s. These elements do show some similarities, especially in their overall shape, to

*Pseudooneotodus* Drygant, 1974. Cooper (1977) reported *Pseudooneotodus beckmanni* (Bischoff and Sannemann) as ranging from the Middle Ordovician to the Lower Devonian. While the elements at hand are quite different from this species, the possibility exists that they may belong to a new genus related to *Pseudooneotodus*.

*Occurrence*: Upper middle part of the Broken Skull Formation (D615:187).

*Material*: 7 specimens

*Illustrated Material*: GSC50380

## Genus Scyphiodus Stauffer, 1935

Type species: Scyphiodus primus Stauffer, 1935

### Scyphiodus sp. s.f.

(Pl. 25, fig. 1)

Description: A species of Scyphiodus that includes a lateral process in addition to the posterior and anterior processes. All processes consist of narrow platforms. The element consists of a narrow, broken posterior process and a wider anterior process that expands beneath the cusp. The cusp is short, pointed and compressed. The posterior process appears to bear low denticles arranged as poorly seen triads, while on the anterior process these denticles are well developed, particularly the last few rows, becoming very prominent distally. Near the apex, there is a lateral process that branches off at right angles to the anterior process. The upper surface of this lateral process has weak denticles, but is broadly keeled. The posterior process may be offset from the main trend. Except for the presence of the lateral process, the unit is quite similar to Scyphiodus primus Stauffer.

Remarks: Illustrations and/or descriptions of this genus are limited to very few papers. I feel that, in most instances, broken elements were reported. The presence of a lateral process, in a manner analogous to that seen in Icriodella, suggests a relationship between Scyphiodus (shallow water) and Icriodella (deeper water), highly reminiscent of the relationship between Polyplacognathus ramosus (a distinctly shallow water form) and other polyplacognathids and/or eoplacognathids that occur in deeper water environments (e.g. Polyplacognathus friendsvillensis, etc.).

Occurrence: From a single collection, P1730:527, from the Sunblood Formation.

Material: 1 specimen

Illustrated Material: GSC50156

### Genus Staufferella Sweet et al., 1975

Type species: Distacodus falcatus Stauffer, 1935a, p. 142, Pl. 12, fig. 16.

Remarks: This genus was established by Sweet et al. (1975) to accommodate acontiodiform and distacodiform elements from the Middle and Upper Ordovician rocks of North America (see discussion of Acontiodus this thesis). The two species, Staufferella falcata and Staufferella lindstroemi, are primarily differentiated on the basis of the presence or absence of a median groove along the broadly convex posterior. My collections include specimens that contain both grooved and non-grooved specimens, but I wonder whether this distinction is a valid criterion for differentiating the two taxa (specimens figured in Pl. 24, figs. 3 and 4, bear only faint grooves).

## Staufferella falcata (Stauffer)

(Pl. 24, figs. 3, 4; Pl. 26, fig. 11)

Distacodus falcatus Stauffer, 1935 , p. 142, Pl. 12, fig. 16; Bergström and Sweet, 1966, p. 329, Pl. 35, figs. 10-13; ?Schopf, 1966, p. 51, Pl. 5, fig. 27; ?Winder, 1966, Pl. 9, fig. 9.

Acontiodus alveolaris Stauffer, 1935a, pp. 601, 602, Pl. 74, fig. 44; Bergström and Sweet, 1966, p. 306, Pl. 35, figs. 16-19; Sweet and Bergström, 1972, p. 32, figs. 1, G.

"Acontiodus" sp. A ? Uyeno, 1974, p. 16, Pl. 1, figs. 24, 25.

Staufferella falcata (Stauffer), Sweet et al., 1975, pp. 44-46, Pl. 1, figs. 10, 11, 18.

Remarks: Only the symmetrical elements are present.

Occurrence: Sporadically through Middle Ordovician rocks of Mackenzie Platform.

Material: 10 specimens

Illustrated Material: GSC50501, GSC50502

## *Staufferella lindstroemi* (Ethington and Schumacher)

(Pl. 24, fig. 2)

*Acontiodus falcatus* Ethington, 1959, p. 268, Pl. 39, figs. 6, 7.

*Acontiodus falcatus* Ethington ? Schopf, 1966, p. 35, Pl. 5, fig. 16.

*Acontiodus lindstroemi* Ethington and Schumacher, 1969, p. 452.

*Staufferella lindstroemi* Sweet *et al.*, 1975, p. 46; Barnes, 1977, p. 108, Pl. 3, figs. 1, 2.

Occurrence: Sporadically through the Middle Ordovician rocks of the southern Mackenzie Platform.

Material: 7 specimens

Illustrated Material: GSC50503

## Genus Stereoconus Branson and Mehl, 1933

Type species: Stereoconus gracilis Branson and Mehl, 1933

Remarks: Moskalenko (1972) has applied a multielemental designation to this genus. The elemental variation according to her includes costate to acostate, and symmetric to asymmetric elements. While this might indeed be the case, at present the genus is treated as a form taxon. Moskalenko (1972) expanded the concept of this genus to include highly costate (even corrugated) elements, a substantial diversion from the original definition.

## Stereoconus sp. s.f.

(Pl. 25, fig. 9)

Diagnosis: A species of Stereoconus having a well rounded cusp, a flared base, and a shallow basal cavity.

Description: The unit consists of simple, cone-shaped elements that have a well rounded cusp outline. The basal cavity is very shallow but the aboral margin is flared and well rounded. Under high magnification, longitudinal striations can be seen. The element is 'fibrous' in composition. It resembles *S. aculeiformis* Moskalenko in its cusp outline, and cusp-to-base relationship. The latter, however, is much taller.

Occurrence: A few collections from the Sunblood and Esbataottine Formations.

Material: 30 specimens (mostly broken).

Illustrated Material: GSC50520

aff. Coelocerodontus stola (Lindström). Lindström, 1964, p. 84, text-fig. 30, p. 51; Ethington, 1972, p. 23; Van Wamel, 1974, pp. 95, 96, Pl. 8, figs. 20-24.

??Acontiodus coniformis Fåhraeus. Ethington and Clark, 1971, p. 77, Pl. 2, figs. 20-24.

Stolodus sp. 1 Serpagli, 1974, pp. 88, 89, Pl. 18, figs. 1a-2c.

Remarks: Klapper et al. (1977) have provided the most recent diagnosis of Stolodus stola. The species at hand fits the general description of the ramiform elements provided in the diagnosis, namely: quadricostate cusp, and very thin basal sheath. However, the elements are not identical with those of S. stola. Moreover, one additional thin-sheathed element that also occurs in the collection has three costae (Pl. 10, fig. 4).

Occurrence: One collection from the Broken Skull Formation (D555:169).

Material: 9 specimens

Illustrated Material: GSC50274, GSC50275, GSC50276, GSC50277

aff. Coelocerodontus stola (Lindström). Lindström, 1964, p. 84, text-fig. 30, p. 51; Ethington, 1972, p. 23; Van Wamel, 1974, pp. 95, 96, Pl. 8, figs. 20-24.

??Acontiodus coniformis Fåhraeus. Ethington and Clark, 1971, p. 77, Pl. 2, figs. 20-24.

Stolodus sp. 1 Serpagli, 1974, pp. 88, 89, Pl. 18, figs. 1a-2c.

Remarks: Klapper et al. (1977) have provided the most recent diagnosis of Stolodus stola. The species at hand fits the general description of the ramiform elements provided in the diagnosis, namely: quadricostate cusp, and very thin basal sheath. However, the elements are not identical with those of S. stola. Moreover, one additional thin-sheathed element that also occurs in the collection has three costae (Pl. 10, fig. 4).

Occurrence: One collection from the Broken Skull Formation (D555:169).

Material: 9 specimens

Illustrated Material: GSC50274, GSC50275, GSC50276, GSC50277

## Genus Strachanognathus Rhodes, 1955

Type species: Strachanognathus parvus Rhodes, 1955

Remarks: Sweet and Bergström (1972) have noted that the apparatus of this genus may be monoelemental.

### Strachanognathus parvus Rhodes s.f.

(Pl. 6, fig. 16)

Strachanognathus parvus Rhodes, 1955, pp. 132, 133, Pl. 8, figs. 1-4; Serpagli, 1967, pp. 71, 72, Pl. 29, figs. 4a-5c (synonymy up to 1964).

Remarks: This taxon is rare in North America and to date has only been reported from Newfoundland (Bergström *et al.*, 1974a). Outside North America it appears to be common but still not abundant.

Occurrence: Road River Formation at Locality 5.

Material: 1 specimen

Illustrated Material: GSC50915

## Genus Triangulodus Van Wamel, 1974

Type species: Paltodus volchovensis Sergeeva, 1963

Definition: Triangulodus is a multielement genus with drepanodiform, scandodiform or paltodiform, acodiform, roundyaform, oistodiform and erect scandodiform elements. Both hyaline conodonts and conodonts with "white matter" belong to this genus (Van Wamel, 1974).

Remarks: But for the presence of erect scandodiform and roundyaform elements, elements of this genus could easily be confused with those of Drepanoistodus or Scandodus sensu Lindström, 1971.

keels. The bases of these elements vary from narrow to broadly triangular, so that the lateral flanges appear short to stretched (antero-posteriorly compressed).

Occurrence: Elements of Triangulodus robustus are present in the basal Sunblood Formation at Section H. A few also occur in the uppermost Broken Skull Formation.

Material: Drepanodiform elements 12, scandodiform elements 21, erect scandodiform elements 11, ?oistodiform elements 8, roundyaform elements 5.

Illustrated Material: GSC50360, GSC50079, GSC50080, GSC50361, GSC50362, GSC50363, GSC50364

keels. The bases of these elements vary from narrow to broadly triangular, so that the lateral flanges appear short to stretched (antero-posteriorly compressed).

Occurrence: Elements of Triangulodus robustus are present in the basal Sunblood Formation at Section H. A few also occur in the uppermost Broken Skull Formation.

Material: Drepanodiform elements 12, scandodiform elements 21, erect scandodiform elements 11, ?oistodiform elements 8, roundyaform elements 5.

Illustrated Material: GSC50360, GSC50079, GSC50080, GSC50361, GSC50362, GSC50363, GSC50364

## Triangulodus n. sp. A

(Pl. 9 , figs. 7, 8, 11-13)

Diagnosis: A multielemental species of Triangulodus that consists of acodiform, paltodiform, erect scandodiform, drepanodiform, and roundyaform elements. Oistodiform elements have not been identified or may be similar to the erect scandodiform elements. The scandodiform, erect scandodiform and drepanodiform elements are characterized by a small base that is slightly offset from a tall, relatively robust cusp. The acodiform and roundyaform elements are symmetrical units that possess a large triangular basal opening. Paltodiform elements also have a drepanodid morphology, but are costate. Elements may or may not possess longitudinal striations or costae.

Description: The drepanodiform elements are proclined units with moderately sharp posterior and anterior edges, and a well developed lateral costa. The base is flared underneath the costa and gives to the unit a slightly twisted appearance.

In the erect scandodiform elements, the anterior and posterior margins are as sharp as the drepanodiform elements, but the lateral costa is poorly developed. The anterior margin becomes prominently keeled laterally and the keel is deflected forwards towards the base. The basal opening appears to be stretched into an ellipse. The oral margin is sharply curved. The elements are erect to slightly reclined. The inner lateral face may possess poorly developed costae (more like striations). The differences between the drepanodiform and scandodiform/erect scandodiform elements of this taxon are difficult to pinpoint.

The paltodiform elements are intermediate between the drepanodiform and erect scandodiform elements. The anterior and posterior margins are sharp and continuous with the base, and the unit is well costate anterolaterally. The base is flared towards the anterior end. The elements are erect to slightly reclined.

The roundyaform elements are bilaterally symmetrical, with keeled antero-lateral and posterior edges. The basal opening is deep and triangular. The posterior margin is not continuous with the oral margin, but makes an angle of about 90°.

Acodiform elements are similar to the roundyaform elements except that they possess no antero-lateral 'flanges'. The cusp is usually erect and is carinate on one side. The basal opening is large, triangular and relatively deep. The base is slightly offset from the cusp and the unit appears somewhat subsymmetric.

Remarks: Oistodiform elements were not recovered. The element identified as Oistodus inaequalis Lindström may, however, belong here.

Occurrence: Lower part of the Broken Skull Formation.

Material: Scandodiform elements (including erect scandodiform ones) 9, paltodiform elements 7, drepanodiform elements 13, acodiform elements 2, roundyaform elements 15.

Illustrated Material: GSC50266, GSC50267, GSC50268, GSC50269, GSC50055

## Triangulodus n. sp. B

(Pl. 24, figs. 1, 5, 6, 7, 8)

Description: The trichonodelliform element of Triangulodus n. sp. B is a bicostate, bilaterally symmetrical unit with an erect to somewhat proclined cusp. Lateral keels are sharp-edged, bisect the sides of the unit longitudinally, and extend from the basal margin to the apex of the cusp. The anterior margin is sharp-edged to narrowly rounded; both the antero-lateral faces of the cusp are flat to slightly convex; and the posterior keel is sharp-edged.

The zygognathiform elements are asymmetric units similar in most of their characteristics to the trichonodelliform elements, but distinguished from them by an extended base such that one of the lateral keels is closer to the sharp-edged posterior margin than the other one.

The acodiform elements are distinguished by the fact that they are costate on only one side; and the other side is broad and flat, or slightly concave.

The drepanodiform elements are compressed, erect to recurved cones with sharp or very narrowly rounded anterior and posterior margins and lanceolate to comma-shaped cross sections.

The oistodiform elements (or erect scandodiform elements) are distinctly asymmetric, with the base more inflated on one side than the other. The cusp is planoconvex, but with a convexity on the side with the inflated base.

The posterior margin of the cusp and the upper margin of the base join to form an angle of about 90°. Elements of Triangulodus n. sp. B in the collections tend to be of the same size, large, black, and opaque.

Occurrence: Triangulodus sp. B is well represented in the upper Chazyan and lower Blackriveran of the Sunblood and Esbataottine formations.

Material: Trichonodelliform elements 8, zygognathiform elements 7, acodiform elements 3, drepanodiform elements 3, oistodiform elements 7.

Illustrated Material: GSC50164, GSC50497, GSC50498, GSC50499, GSC50560

Genus Trichonodella Branson and Mehl, 1948

Remarks: Trichonodelliform elements usually form one of the elements of apparatuses belonging to such multielement taxa as Plectodina or Oulodus. Sometimes, however, these elements are difficult to associate with a specific taxon. In such instances, the genus is treated under form taxonomy.

Trichonodella longa minor Lindström s.f.
(Pl. 2, fig. 17)

Trichonodella longa minor Lindström, 1955, p. 601, Pl. 6, figs. 16-19.

Remarks: The unit at hand is similar to T. longa minor Lindström except for the presence of lesser numbers of serrations. More appropriately it is intermediate between T. longa minor and T. longa Lindström, which is adentate. Van Wamel (1974) included this with the apparatus of Acodus deltatus deltatus Lindström.

Occurrence: Road River Formation at Section K (K2020:616).

Material: 1 specimen

Illustrated Material: GSC50873

### Trichonodella sp. 1 s.f.

(Pl. 14, fig. 17)

Diagnosis: The unit consists of an erect cusp bearing two lateral alar-like processes. All three processes carry poorly developed denticles. The aboral cavity is broadly triangular with a flare underneath the posterior margin.

Description: The cusp is erect, antero-posteriorly compressed, with a broadly rounded anterior margin. It is strongly keeled antero-laterally and posteriorly; thus giving it an acontiodiform outline. The lateral sides extend basally into processes that are of subequal length and carry a few poorly developed denticles. The entire unit appears highly symmetrical. The posterior process bears two denticles towards the lower half, the proximal smaller than the distal. The denticles probably are discrete, and tend to lean away from the cusp distally. The basal opening is shaped like a broad triangle with a flare beneath the posterior process.

Remarks: The unit probably has a hyaline composition. It resembles *Acontiodus bialatus* Mound in its general cusp-to-base arrangement and shape of the cusp.

Occurrence: From the basal Whiterockian of the Sunblood Formation at Section H.

Illustrated Material: GSC50084

## Trichonodella ? sp. s.f.

(Pl. 15, fig. 12)

Description: A bilaterally symmetrical element with a reduced base. A strong costa runs along the mid-posterior. The anterior surface has antero-lateral edges forming flange-like extensions. The basal opening occupies a small area under the cusp, but it expands into grooves beneath the two lateral flanges.

Remarks: This element, in almost every way, resembles the deltaform element of the multielement taxon *Oistodus papiliosus* Van Wamel. Serpagli (1974) found elements that were identical to the triangulariform element of *O. papiliosus* (New Genus B n. sp. 1 of Serpagli). However, no accompanying deltaform element was found. It is difficult to either prove or reject Van Wamel's reconstruction at this stage. Hence, I prefer to treat the element described here as a form-taxon.

Occurrence: Basal part of the Sunblood Formation at Section H.

Material: 1 specimen

Illustrated Material: GSC50086

### Genus *Walliserodus* Serpagli, 1967

*Type species:* *Paltodus debolti* Rexroad, 1967

*Remarks:* This genus was erected by Serpagli (1967) to include simple cone elements arranged in a transition series, which are characterized by several longitudinal keel-like costae and by a deep basal cavity, which, however, does not reach the top of the units. Based on a study of Silurian conodonts, Cooper (1977) has given it a multielemental designation.

### *Walliserodus ethingtoni* (Fåhraeus)
### (Pl. 4, fig. 10; Pl. 7, fig.5)

*Panderodus ethingtoni* Fåhraeus, 1966, p. 26, Pl. III, figs. 5a, 5b.

*Remarks:* The specimens included in this species fit the description provided by Fåhraeus (1966), except that the posterior margin is less sharp. I do not believe that this feature is significant enough to separate the form into a new species. Although Fåhraeus included these under *Panderodus*, the forms appear to qualify better for placement into *Walliserodus*.

*Occurrence:* Road River Formation at Locality 5.

*Material:* 8 specimens

*Illustrated Material:* GSC50924, GSC50925

## Walliserodus sp. aff. W. australis Serpagli

(Pl. 10, figs. 11, 14-20)

aff. Walliserodus australis Serpagli, 1974, pp. 89-91, Pl. 19, figs. 10a-c, Pl. 29, figs. 8-15, text-figs. 23, 24; Landing, 1976, pp. 641, 642, Pl. 4, figs. 16, 19, 22, 23.

Remarks: As described by Serpagli (1974), elements of W. australis form a transition series from three costate to multicostate elements characterized by strong keel-like costae and a moderately deep basal cavity, not extending into the cusp. Elements of three, four and five costae present in the Broken Skull Formation can be accommodated within the definition of W. australis. However, no multicostate element, with more than five costae, was recovered. Neither was the four-costate element of the type illustrated in Pl. 29, fig. 15 of Serpagli. The three costate and five costate elements are, however, quite close to those of W. australis. For this reason, I believe that the species at hand is not conspecific with W. australis Serpagli.

Occurrence: Lower middle part of the Broken Skull Formation.

Material: 3 costate elements 57, 4 costate elements 8, 5 costate elements 4.

Illustrated Material: GSC50285, GSC50286, GSC50287, GSC50288, GSC50289, GSC50290, GSC50291, GSC50057

### Walliserodus ? sp. s.f.

(Pl. 16, fig. 10)

Remarks: A robust four costate element with a large flaring deeply excavated base shows some similarity to the four-costate element of W. australis Serpagli. However, the robustness of the element, the large base and possibly younger stratigraphic position would not justify my placing it in the same multielement species as the elements of W. sp. aff. W. australis.

Occurrence: Uppermost Broken Skull Formation.

Material: 1 specimen

Illustrated Material: GSC50379

### Genus Westergaardodina Müller, 1959

Type species: Westergaardodina bicuspidata Müller, 1959

Remarks: This genus includes U or W-shaped phosphatic elements that normally lack white matter. Lindström (1970) included them in the Order Westergaardodina and separated them from the Order Conodontophorida which he regarded as the true conodonts. The stratigraphic range of this genus is restricted to the Cambrian and Lower Ordovician. The Late Cambrian specimen, Westergaardodina ? sp. 1, is almost amber coloured and has a pitted surface. The Lower Ordovician specimen, Westergaardodina ? sp. 2, is black and well preserved.

## Westergaardodina ? sp. 1 s.f.

(Pl. 1, fig. 7)

Description: A U-shaped form with sides (arms?) forming an angle of about 90°. The two sides (arms?) may be of unequal lengths with flat outer and convex inner faces. The specimen is amber-coloured and appears to be etched at the surface (pitted appearance). The basal cavity, if any, cannot be seen; neither can a median denticle.

Occurrence: The specimen occurs in the Proconodontus Zone of the Rabbitkettle Formation (K715:218).

Material: 1 specimen

Illustrated Material: GSC50S53

### Westergaardodina ? sp. 2

(Pl. 8, fig. 8)

Description: A species of Westergaardodina with nearly flat base and almost erect sides (arms?). The basal ledge is very tall compared to most westergaardodinids. The oral edge of this ledge is smoothly curved into a U. The cross-section of the two arms differs, but both show a thicker inside edge that projects onto the aboral margin of the unit.

Occurrence: From the Broken Skull Formation.

Material: 1 specimen

Illustrated Material: GSC50253

## New Genus A Sweet, Ethington and Barnes

(Pl. 15, figs. 5, 7, 10)

ramiform element

New genus and species Ethington and Clark, 1965, p. 203, Pl. 2, fig. 17.

New Genus A Sweet, Ethington and Barnes, 1971, p. 168, Pl. 1, fig. 19 (only). Barnes, 1974, p. 236, Pl. 1, fig. 5 (only).

oistodiform element

*Oistodus* sp. B Ethington and Clark, 1965, p. 196, Pl. 2, fig. 11.

New Genus A Sweet, Ethington and Barnes, 1971, p. 168, Pl. 1, fig. 22 (only). Barnes, 1974, p. 236, Pl. 1, fig. 4 (only).

*Remarks*: This multielement taxon contains ramiform and oistodiform elements. Both are characterized by a ledge parallel to and slightly above the basal margin. The oistodiform and ramiform elements have been described by Ethington and Clark (1965) as *Oistodus* sp. B and New genus and species, respectively. These same elements have also been illustrated (Ethington and Clark, 1965; Sweet *et al*., 1971). Both elements show a considerable amount of variation. It is possible that elements included in *Oelandodus costatus* Van Wamel in some ways resemble this taxon. For instance, compare the elongathiform element and triangulariform elements of O. costatus (Van Wamel, 1974, Pl. 7, figs. 5 and 6) with Oistodus sp. B and New genus and species Ethington and Clark, 1965 (Pl. 2, figs. 11 and 17 respectively). However, I do not believe that the two are conspecific. It is quite likely that the difference may be attributed to a geographic separation. However, my collections also include representatives of Oelandodus Van Wamel.

Occurrence: Basal Sunblood Formation at Section H.

Material: Oistodiform elements 62, ramiform elements 28.

Illustrated Material: GSC50365, GSC50366, GSC50075

## New Genus B n. sp. Barnes s.f.

(Pl. 16, fig. 4)

New Genus B Sweet, Ethington and Barnes, 1971, Pl. 1, fig. 34; Barnes, 1974, Pl. 1, fig. 9.

New Genus B n. sp. Barnes s.f., 1977, p. 104, Pl. 1, figs. 16-18.

Remarks: This taxon has been fully described by Barnes (1977). It is believed to be the index taxon of Fauna 1 of Sweet *et al.*, 1971.

Occurrence: Basal Sunblood Formation at Section H.

Material: 1 specimen

Illustrated Material: GSC50378

### New Genus C Sweet, Ethington and Barnes s.f.

(Pl. 19, fig. 16)

New Genus C Sweet, Ethington and Barnes, 1971, Pl. 1, fig. 25.

Description: The only conodont element of this taxon in my collection is probably somewhat deformed. It consists of three denticles; the central one is larger and much taller than the other two. It is compressed antero-posteriorly, but the cross section is not flat because of the presence of a blunt costa on the posterior margin. This costa continues downwards and meets the upper margin of one lateral denticle. The anterior margin is broadly rounded and also costate. One side of this margin meets the upper surface of the other lateral denticle. The cusp, therefore, gives the impression of having been twisted around itself. The two lateral denticles are of equal size. The basal opening expands underneath them and is reduced (or absent) beneath the main denticle.

Remarks: The element has an overall multioistodid shape and is reminiscent of cladognathiform elements of *M. subdentatus* described in this study. It also shows some resemblance to *Pteracontiodus exilis* (Harris), illustrated on the same plate (Pl. 19, fig. 20).

Occurrence: Whiterockian collection B400:122 from the Sunblood Formation.

**Material:** 1 specimen

**Illustrated**

**Material:** GSC50109

New Genus A n. sp. 1 Serpagli

(Pl. 16, figs. 9, 11)

Gen. Nov. A n. sp. 1 Serpagli, pp. 92, 93, Pl. 19, figs. 1a-3c; Pl. 29, figs. 1-3, text-fig. 25

Remarks: Elements of this taxon were included by Landing (1976) in the apparatus of Periodon flabellum (Lindström). He regarded them as juvenile ozarkodiniform elements that began as small Oistodus-like elements to which denticles were added first to the posterior process and then to the anterior. Serpagli (1974) in fact observed that his reconstruction of this taxon may be incomplete. However, surprisingly, elements of this taxon share only one collection in common with that containing P. flabellum. Until more data become available, I prefer to regard Serpagli's New Genus A n. sp. 1 as belonging to a separate taxon. The acodiform and drepanodiform elements of this species show a symmetry transition similar to Triangulodus Van Wamel (drepanodiform, erect scandodiform, scandodiform, and oistodiform).

Occurrence: Upper samples from the Broken Skull Formation and basal Sunblood Formation.

Material: Drepanodiform elements 8, acodiform elements 3.

Illustrated Material: GSC50378, GSC50376

## New Genus New Species A

(Pl. 3, figs. 13-16)

Diagnosis: Elements of this taxon probably belong to a transition series consisting of falodiform? (oistodiform), cordylodiform? and trichonodelliform elements. The apparatus is probably incomplete. Most elements display a cellular type of microsculpture, possess a downward anterior extension (anticusp) and occur in the same collection.

Description: The trichonodelliform element is similar to the homologous element of Periodon aculeatus Hadding (early form). It differs from the latter by the general robustness of the cusp and denticles. The cusp in this case is usually thicker and distinctly costate laterally, with or without a posterior groove. It usually has an anticusp that extends downwards in continuation of the anterior margin or may be slightly deflected upwards. The denticles occur on all three processes, the two lateral and the posterior. However, most denticles are broken. Little can be said about their numbers. It appears, however, that denticles are more slender and probably more compressed (flattened?) than the cusp. The basal opening appears to follow the outline of the main cusp as well as the three processes. Falodiform element?: This element is characterized by an anteriorly extended base and a short, somewhat stubby cusp. The entire unit is compressed laterally. Neither margins, however, are sharp. The posterior margin carries up to six fine striations that become more conspicuous towards the base. The anterior margin is almost rounded and makes a sharp angle with the aboral margin. The basal opening is shaped like an elongated ellipse. A fine cellular microsculpture is present over the entire lower half of the unit.

Cordylodiform? element: The configuration of this element is similar to Oistodus in that the cusp is inclined to the base at a sharp angle. The base is short and relatively low as compared to the cusp, which is moderately tall and wide. It carries a faint costa on the outside that continues on to the base. At the site of the termination of the costa, a single denticle is present that occupies an 'in between' position between the posterior process below and the cusp above. Both the anterior and posterior margins of the cusp are sharp, the former becoming subrounded at the base. The basal opening occupies the underside of the base and appears to widen towards the anterior end.

Occurrence: Collection K2375:724 of the Road River Formation.

Material: Trichonodelliform elements 2, falodiform element 1, cordylodiform elements? 3.

Illustrated Material: GSC50886, GSC50887, GSC50888, GSC50889

## New Genus New Species B

(Pl. 8, figs. 4, 6, 7, 11)

Diagnosis: Simple hollow, extremely thin-walled coelocerodontid-like elements, transition as from subtriangular cones to strongly compressed cones, generally characterized by low broad transverse ridges.

Remarks: Although morphologically the elements included in this taxon are quite distinct from one another, their constant size and colour, their extremely thin-walled sheaths, the presence of broad transverse ridges, and their co-occurrence in the same collection suggests a possible 'natural' relationship between these elements. Coelocerodontid element: This unit has a diamond-shaped cross section, with well developed posterior and lateral keels and a subrounded anterior margin. The keeled edges appear to be serrated. The entire unit is hollow, thin-sheathed and carries several transverse 'ridges' along the lateral faces.

Coelocerodontid? element 1: This unit is compressed laterally so that the posterior margin is very sharp while the anterior margin is bluntly rounded basally but becomes sharper apically. Two low costae are present in the lower half of the anterior margin, and terminate near the base. Two apparent lateral costae begin near the apex and terminate above the midway point of the lateral faces. The unit is hollow, and an elliptical basal opening has a much sharper posterior end than anterior end. Low transverse ridges are developed along the sides.

Coelocerodontid? element 2: This unit has a sharp antero-lateral costa as well as sharp anterior and posterior margins. Two of the three margins (anterior and antero-lateral) carry traces of incipient serrations (nodes?).

Acontiodid? element: I include this unit here with some reservations. The element is acontiodid-like in the sense that it has a broad, flat anterior face that projects laterally to form flanges or 'wings' and a sharp posterior costa at right angles to the anterior face. The two extended flanges and the posterior costa are equally wide and thick. The anterior face appears to be stretched downwards.

Remarks: All elements included in this taxon show some similarities with elements of Stolodus sp. aff. S. stola described elsewhere. This includes size, colour and thinness of the basal sheath.

Occurrence: From collection D555:169 of the Broken Skull Formation.

Material: Coelocerodontid elements 3, coelocerodontid? element 2:3, coelocerodontid? element 1:2, acontiodid? element 1.

Illustrated Material: GSC50249, GSC50250, GSC50251, GSC50252

## New Genus New Species C

(Pl. 8, figs. 9, 10, 12-14)

Diagnosis: A multielemental species that includes thin sheathed elements showing two morphotypes. Type 1 includes hollow triangular elements consisting of three faces diverging from an apex, the edges of which are incipiently to well serrated. Type 2 includes antero-posteriorly stretched, hollow units that bear a short to well developed cusp.

Description: 'Serratus' elements: Thin walled, triangular elements having deep basal cavities consisting of symmetric to asymmetric units. The symmetric unit has three subequal edges that are moderate to well keeled and bear incipient serrations. The faces (area between the edges) of these units are plane to concave inwards and contain broad, transverse, poorly-developed ridges. The asymmetric element usually has one of the edges longer than the other two. This longer edge tends to bear more conspicuous serrations that are more widely separated. The two lateral faces are concave inwards.

The aboral margin varies from broadly triangular underneath the symmetric elements to somewhat elliptical underneath the asymmetric units.

'Planus' (?) elements: These units are stretched antero-posterior. They too are hollow and thin sheathed. The cusp varies from a short protrusion above the oral margin to a significant distance above it. To some extent, the elements appear to show traces of incipient serrations towards the upper edges.

The terms 'serratus' and 'planus' were used by Serpagli (1974) to describe hollow, thin sheathed units that also possessed nodes. However, morphologically, the elements at hand are quite different. Serpagli (1974) questionably included these elements under genus Fryxellodontus Miller.

Occurrence: From a single collection, D555:169, Broken Skull Formation.

Material: 'Planus' elements 5, 'serratus' elements 7

Illustrated Material: GSC50254, GSC50255, GSC50256, GSC50257, GSC50258

## New Genus New Species D

(Pl. 18, figs. 10-13, 15)

Diagnosis: A multiramiform taxon consisting of trichonodelliform, zygognathiform, cordylodiform and dichognathiform elements. All the elements are characterized by a tall, thin cusp that has a median costa along its axis; and denticles diverging from the cusp. These are shaped like the median cusp, and reach to its mid-height. A microsculpture consisting of fine longitudinal striations is present on all of the elements.

Description: Trichonodelliform elements consist of 3 to 5 denticles. The cusp is tall, sharp-edged, compressed, and very erect, with a keel on the median region of the cusp. The lateral denticles are symmetrically disposed at an angle of about 30-45° to the cusp, and may vary from 1-3 on either side. The processes are keeled in a similar fashion to the cusp. The basal opening appears to be restricted to the cusp only, at the apex of an inverted, V-shaped, aboral profile.

The zygognathiform element is easy to place in the symmetry transition of this taxon, but differs in several details from the trichonodelliform element. The median keel that is prominently displayed in the trichonodelliform element is very poorly developed. No central denticle is present (the cusp is not prominent). The unit varies from subsymmetric to asymmetric. The aboral profile is less sharply curved upwards, and the basal opening is elongated and present underneath several denticles. Although no median denticle is present, usually one of these is taller. The arrangement of the denticles varies from rather closely packed to divergent.

Cordylodiform elements also possess a keeled cusp and denticles. The cusp is usually very erect, highly compressed and sharply edged posteriorly and anteriorly. The posterior process is slightly arched and sinuous(?) and a large secondary denticle diverging away from the cusp immediately follows the main cusp. This feature is noted also in Cordylodus sp. aff. C. horridus, from the same collection. Accompanying secondary denticles are tightly packed and lean away from the cusp (also reminiscent of C. sp. aff. C. horridus). Were it not for the presence of its distinctive microsculpture, I would have considered including this element in C. sp. aff. C. horridus as its cordylodiform element. Dichognathiform elements usually have a tall, erect cusp that appears to be well costate laterally and keeled antero-posteriorly. There is a hint of a lateral process. The posterior process is usually short, and contains up to 4 denticles. The larger secondary denticle once again is near the cusp, and leans away from it. However, it is much smaller in size and height than the cusp. A subtriangular basal opening is present.

Occurrence: A Whiterockian collection from the Sunblood Formation.

Material: Trichonodelliform elements 9, zygognathiform elements 7, cordylodiform elements 7, dichognathiform elements 2.

Illustrated Material: GSC50419, GSC50420, GSC50421, GSC50422, GSC 50742

## New Genus New Species 1 s.f.

(Pl. 1, fig. 11)

Description: A minute oneotodid-like element having a sharp anterior margin which is sharp and keel-like basally, and an equally sharp posterior margin that is serrated at mid height. The apical end of the element is deflected upwards. The base is twisted in relation to the cusp. The basal opening is rounded in outline; it is flared posteriorly, and extends into a sharp point anteriorly.

Remarks: The element shows some affinity with *Oistodus minutus* Miller, except for a more pronounced twisting of the base. The presence of the serrations in conodonts of this level is known in *Proconodontus serratus* Miller *sensu* Müller, 1973. It appears that this feature may be more prevalent than previously realized. Similarly, the oral upturning of the cusp is present in *Oneotodus datsonensis* Druce and Jones (1971). The present specimen shows this at a much more pronounced level.

Occurrence: From the *Proconodontus* Zone (K715:218) of the Rabbitkettle Formation.

Material: 1 specimen

Illustrated Material: GSC5[illegible]58

## New Genus New Species 2 s.f.

(Pl. 5, fig. 8)

Diagnosis: A pyramid-shaped unit consisting of three sides, each of which is denticulated with minute nodes. The faces between the arms are part of a very thin sheath, and are concave to plane. A broad shallow basal opening is present.

Description: The general shape of this unit, in side view, is that of a three-sided pyramid. All three margins are straight and bear a row of small, inconspicuous teeth or nodes. The three rows are joined by a thin sheath such that the lateral faces are concave while the 'anterior' face is almost flat to broadly concave.

The aboral side of the specimen shows a broad but shallow triangular excavation. It is possible that the unit may have had a deep basal opening that has been filled with phosphatic matrix. In plan view, the unit consists of three downwardly directed arms (rows) bearing small nodes that meet apically near the top, which is broken. The three arms make sharp angles with the vertical

Remarks: The element shows some similarities to Nericodus Lindström and Pygodus ? sp. of this study, both of which generally possess a deep basal cavity.

Occurrence: Collection K2375:724 from the Road River Formation.

Material: 1 specimen

Illustrated
Material:    GSC50298

## New Genus New Species 3 s.f.

(Pl. 26, fig. 21)

Diagnosis: A minute platform-like element having a deep, triangular basal opening and a flat rectangular ridge-like structure that appears to be serrated towards the upper side into four subequal, thick, short and confluent denticles.

Description: The unit consists of a sharp and flat ridge-like upper part that widens basally into a deep triangular opening that is sharply angular at two ends and makes an obtuse angle at the third (lateral) end, thereby giving the appearance of an equilateral triangle for the aboral profile. The apical (front?) denticle is joined to the base by means of a gently sloping face whose lower margin meets one side of the triangular basal cavity. Immediately below the denticles, there is a broad raised ridge (ramp?) that separates the base from the denticulated upper region. There are four incipient denticles that are similar in size, orientation and height.

The element appears to be new and shows a spathognathodid profile.

Occurrence: Whittaker Formation.

Material: 1 specimen

Illustrated Material: GSC50185

## FORM A

(Pl. 27, fig. 1)

Remarks: These phosphatic moulds resemble the late Cambrian conodont *Oneotodus bulbousus* Miller. Klapper *et al.* (1973) have included the latter in the genus '*Hirsutodontus*' Miller.

Occurrence: Lower part of the Rabbitkettle Formation.

Material: 29 specimens

Illustrated Material: GSC50001

## FORM B

(Pl. 27, fig. 2)

Remarks: These forms probably represent paraconodonts (lacking any white matter). The shape and surface sculpture suggests relationship with the genus '*Probelemaconites*' Müller.

Occurrence: Low in the Rabbitkettle Formation.

Material: 12 specimens

Illustrated Material: GSC50000

### FORM C

(Pl. 27, fig. 3)

Remarks: This form probably represents a phosphatic mould of the primitive gastropod Pelagiella Matthews.

Occurrence: Low in the Rabbitkettle Formation.

Material: 3 specimens

Illustrated Material: GSC50700

### FORM D

(Pl. 27, fig. 4)

Remarks: Phosphatic microfossil having an elongated basal opening, a domed top and a spine-like protusion (cusp?) somewhat reminiscent of the genus Clavohamulus Furnish. Surface has a highly pitted appearance.

Occurrence: Low in the Rabbitkettle Formation.

Material: 1 specimen

Illustrated Material: GSC50701

## FORM E

(Pl. 27, fig. 6)

*Remarks*: These forms are similar to the primitive phosphatic gastropod *Anabarella indecora* Kobayashi. In the light of the recent revision of these primitive gastropods by Runnegar and Jell (1977) they probably should be included in the genus *Mellopegma* Runnegar and Jell.

*Occurrence*: Low in the Rabbitkettle Formation.

*Material*: 32 specimens

*Illustrated Material*: GSC50003

## FORM F

(Pl. 27, fig. 7)

*Remarks*: A primitive platform element having a deep flared basal opening and a sharp keel-like structure at the top, that is rough, corroded (?) and slightly sinuous when viewed from above.

*Occurrence*: Uppermost part of the Rabbitkettle Formation.

*Material*: 1 specimen

*Illustrated Material*: GSC50703

## FORM G

(Pl. 27, fig. 8)

Remarks: Primitive microfossil similar to the Cambrian problematic taxon, Sachites proboscideus Meshkova.

Occurrence: Lower part of the Rabbitkettle Formation.

Material: 2 specimens

Illustrated Material: GSC50704

## FORM H

(Pl. 27, fig. 9)

Remarks: A primitive platform (amorphognathiform?) element. Neither the oral denticles nor the aboral cavity is developed.

Occurrence: Uppermost Rabbitkettle Formation.

Material: 1 specimen

Illustrated Material: GSC50705

## FORM I

(Pl. 27, fig. 10)

Remarks: Phosphatic microfossil belonging to the genus *Milaculum* Müller, probably *M. scandicum* Müller.

Occurrence: Uppermost part of the Broken Skull Formation.

Material: 3 specimens

Illustrated Material: GSC50706

## FORM J

(Pl. 27, fig. 11)

Remarks: This form resembles the saggitodontiform elements of genus *Icriodella*. No icriodellan element was present in the sample. The element has four edges; the two side ones (lateral?) are long and downward directed at angles of about 45° from a central point whereas the other two edges (front and back?) are less distinct, short and downward directed at much steeper angles. The entire unit is hollow and deep with the basal cavity extending right up to the tip.

Occurrence: In the Sunblood Formation at Section A, sample A 125:38.

Material: 4 specimens

Illustrated Material: GSC50707

## FORM K

(Pl. 27, fig. 12)

Remarks: These tri-radiating phosphatic objects are common in Late Ordovician rocks of the Midcontinent (I found them in several samples sent by D. Kennedy). They probably have not been illustrated before.

Occurrence: Whittaker Formation at Section D (D 1668:508) and Section E (E 2540:774).

Material: 21 specimens

Illustrated Material: GSC50708

## FORM L

(Pl. 27, fig. 13)

Remarks: These open hollow cone-shaped phosphatic elements have only recently been included in the conodonts (see Dzik, 1976). The elements illustrated here probably belong to the genus *Oneotodus* as suggested by Dzik (op. cit.) and not *Ambalodus* as was noted by Moskalenko (1973).

Occurrence: From the Road River Formation at Locality 5.

Material: 4 specimens

Illustrated Material: GSC50709

### FORM M

(Pl. 27, fig. 14)

Remarks: This element has some superficial similarities with conodonts or trilobite spines but the composition and surface microsculpture are quite different.

Occurrence: From the Broken Skull Formation, Section D (D450:137).

Material: 1 specimen

Illustrated Material: GSC50710

### FORM N

(Pl. 27, fig. 15)

Remarks: This phosphatic microfossil has a surface sculpture similar to the genus *Utahphosphia* Müller and Miller. It, however, lacks the cone shape typical of that genus. Some resemblance to the genus *Milaculum* Müller is also noted.

Occurrence: From the Road River Formation at Locality 5.

Material: 4 specimens

Illustrated Material: GSC50711

## FORM O

(Pl. 27, fig. 16)

Remarks: This form is identical to Milaculum ethinclarki Müller, a characteristic Ordovician phosphatic microfossil.

Occurrence: From the Broken Skull Formation at Section D (D 840:256 and D 860:262).

Material: 4 specimens

Illustrated Material: GSC50712

## Form P

(Pl. 26, fig. 18)

Remarks: These hollow, phosphatic cones were previously identified as Ambalodus mitratus mitratus by Moskalenko (1973). Dzik (1976) suggested that they probably belong to Oneotodus. Recently, B.D.E. Chatterton (personal communication) has found these elements to be associated with the basal fillings of inarticulate brachiopods, thereby pointing out the possibility that these may not be conodonts.

Occurrence: Several collections from the Whittaker Formation.

Material: 18 specimens

Illustrated Material: GSC50182

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| FORMATION: | RABBITKETTLE | | | | | |
|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | 300.2 | 263.6 | 222.5 | 164.6 | 114.3 | 79.2 |
| SAMPLE NUMBER: | K270 | K390 | K525 | K715 | K880 | K995 |
| TAXA: | | | | | | |
| CORDYLODUS PROAVUS s.f. s.l. | | | | | 23 | |
| DREPANODUS sp. ? | | | | | | 1 |
| "DREPANODUS" spp. s.f. | | | 1 | 2 | 4 | 1 |
| 'FURNISHINA' ? sp. s.f. | | 1 | 1 | | | |
| 'HERTZINA' ? sp. s.f. | | | 1 | | | |
| "OISTODUS: CAMBRICUS s.f. | | | | 1 | | |
| ONEOTODUS ERECTUS s.f. | | | | | 1 | |
| ONEOTODUS GRACILIS s.f. | | | | 2 | 3 | 3 |
| ONEOTODUS NAKAMURI s.f. | | | | 2 | 2 | 3 |
| ONETODUS n. sp. A s.f. | | | | | 16 | 5 |
| NEW GENUS NEW SPECIES 1 s.f. | | | | 1 | | |
| "PALTODUS" UTAHENSIS ? s.f. | | | | 1 | | |
| 'PROONEOTODUS' TENUIS s.f. | | | 1 | | | |
| PROCONODONTUS ROTUNDATUS s.f. | | | 1 | 6 | 1 | |
| PROCONODONTUS NOTCHPEAKENSIS s.f. | | | | 4 | 2 | |
| PROCONODONTUS. MUELLERI MUELLERI s.f. | | | 4 | 12 | 5 | |
| PROCONODONTUS cf. P. MUELLERI MUELLERI s.f. | | | | 1 | 2 | 1 |
| PROCONODONTUS ? sp. s.f. | | | 8 | | | |
| PROCONODONTUS ? PRIMITIVUS s.f. | | | 1 | | 1 | |
| WESTERGAARDODINA ? sp. 1 s.f. | | | | 1 | | |

TABLE I

| FORMATION: | ROAD RIVER | | | | | | |
|---|---|---|---|---|---|---|---|
| DISTANCE ABOVE THE FORMATION: | | | | | | | |
| DISTANCE ABOVE THE BASE IN METERS: | 19.8 | 56.4 | 65.5 | 77.7 | 94.5 | 111.2 | 141.7 |
| SAMPLE NUMBER: | K1900 | K2020 | K2050 | K2090 | K2145 | K2200 | K2300 |
| TAXA: | | | | | | | |
| ACODUS n. sp. A | 7 | 1 | 2 | | | | |
| ACODUS ERECTUS | | 1 | | | | | |
| ACODUS GLADIATUS | | | | 1 | | | |
| DREPANODUS ARCUATUS s.l. | | | | | | | 1 |
| DREPANOISTODUS FORCEPS | 4 | 2 | 8 | | | | |
| GOTHODOS MICRODENTATUS s.f. | | | 1 | 1 | | | |
| OEPIKODUS EVAE | | 8 | 12 | 4 | | | |
| OISTODUS LANCEOLATUS | | 3 | 3 | | | | |
| ONETODUS VARIABILIS s.f. | 2 | | | | | | |
| PERIODON FLABELLUM? | | | | 1 | 2 | | |
| PARACORDYLODUS GRACILIS | | 1 | 3 | | | | |
| PAROISTODUS PARALLELUS s.l. | | 1 | 1 | | | | |
| PRIONIODUS CRASSULUS | | | | 1 | 4 | | |
| PRIONIODUS ELEGANS ? | | 3 | 1 | | | | |
| PROTOPANDERODUS RECTUS | 4 | 2 | | | | | |
| TRICHONODELLA LONGA MINOR s.f. | | 1 | | | | | |

TABLE II

CONODONTS FROM THE ROAD RIVER FORMATION AT SECTION K, K2375 (164.6 METERS AVOVE THE BASE OF THE FORMATION).

| TAXA: | |
|---|---|
| ACONTIODUS ROBUSTUS | 5 |
| CORDYLODUS RAMOSUS | 9 |
| DREPANODUS ARCUATUS s.l. | 8 |
| DREPANOISTODUS BASIOVALIS s.l. | 8 |
| EOPLACOGNATHUS PLANUS | 11 |
| EOPLACOGNATHUS n. sp. A | 13 |
| KEISLOGNATHUS sp. aff. K. PYRAMIDALIS s.f. | 1 |
| LEPTOCHIROGNATHUS n. sp. A | 3 |
| MULTIOSTODUS SUBDENTATUS | 3 |
| NEW GENUS NEW SPECIES A | 6 |
| NEW GENUS NEW SPECIES 2 s.f. | 1 |
| OISTODUS VENUSTUS s.f. | 2 |
| PAROISTODUS PARALLELUS s.l. | 7 |
| PERIODON ACULEATUS (early form) | 95 |
| PROTOPANDERODUS COOPERI s.l. | >100 |
| PYGODUS n. sp. 1 Uyeno and Barnes 1970, s.f. | 1 |
| RHODESOGNATHUS n. sp. A ? | 6 |
| SCANDODUS sp. s.f. | 1 |

TABLE III

CONODONTS FROM LOCALITY 5, ROAD RIVER FORMATION
(indeterminate stratigraphic position within formation)

| TAXA: | |
|---|---|
| ACODUS MUTATUS | 6 |
| ACONTIODUS ROBUSTUS s.f. | 10 |
| BELODELLA sp. aff. B n. sp. Barnes and Poplawski | 5 |
| BELODINA MONITERENSIS MARGINATA | 3 |
| CHIROGNATHUS ? sp. s.f. | 2 |
| DREPANODUS ARCUATUS s.l. | 5 |
| DREPANOISTODUS BASIOVALIS s.l. | 6 |
| DREPANOISTODUS FORCEPS | 5 |
| PANDERODUS GRACILIS | 25 |
| PAROISTODUS PARALLELUS ? s.l. | 6 |
| PERIODON ACULEATUS | 19 |
| PHRAGMODUS n. sp. B. | 10 |
| POLYPLACOGNATUS FRIENDSVILLENSIS | 8 |
| POLYPLACOGNATHUS sp. ? | 1 |
| PROTOPANDERODUS INSCULPTUS | 2 |
| PROTOPANDERODUS COOPERI s.l. | 30 |
| PYGODUS SERRUS | 110 |
| STRACHANOGNATHUS PARVUS s.f. | 1 |
| WALLISERODUS ETHINGTONI | 8 |

TABLE IV

| FORMATION | ROAD RIVER | | | | |
|---|---|---|---|---|---|
| SAMPLE LOCALITY NUMBER | Loc. 1. | Loc. 2. | Loc. 3. | Loc. 4. | G4460 |
| TAXA: | | | | | |
| ACODUS MUTATUS | | 1 | | | |
| AMORPHOGNATHUS SUPERBUS | | 10 | | | |
| DREPANOISTODUS BASIOVALIS s.l. | | 3 | | | |
| DREPANOISTODUS SUBERECTUS | 2 | 3 | 3 | 4 | 2 |
| PANDERODUS GRACILIS | 10 | 1 | 2 | 16 | 6 |
| PERIODON GRANDIS | 2 | 11 | 1 | 1 | |
| PLECTODINA FURCATA | 2 | | 2 | 1 | |
| PROTOPANDERODUS INSCULPTUS | | 2 | 2 | 1 | |

TABLE V

| FORMATION: | BROKEN SKULL | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS | 196.6 | 191.1 | 174.3 | 147.8 | 132.6 | 123.4 | 114.3 | 93.0 | 74.7 |
| SAMPLE NUMBER: | D215 | D233 | D288 | D375 | D420 | D450 | D485 | D555 | D615 |
| TAXA: | | | | | | | | | |
| ACODUS DELTATUS DELTATUS | | | | 24 | 12 | 30 | 3 | 19 | |
| ACODUS SWEETI | | | | 3 | 3 | 4 | 2 | | |
| COELOCERODONTUS n. sp. A | | | 4 | 8 | 2 | 1 | 1 | | |
| DREPANODUS ARCUATUS | 70 | 35 | 34 | 29 | 22 | 24 | 22 | 11 | |
| DREPANODUS sp. aff. D. sp. Sweet & Bergstrom s.f. | | | 1 | | | | | | |
| DREPANODUS sp. s.f. | | | 4 | | | | | | |
| DREPANOISTODUS CONULATUS | | | | 8 | 6 | 16 | 7 | 3 | 2 |
| DREPANOISTODUS FORCEPS | | 7 | 5 | 7 | 9 | 13 | 10 | 8 | 3 |
| JUANOGNATHUS JAANUSSONI | | 4 | 5 | 7 | 5 | 1 | 5 | 7 | |
| MILACULUM PERFORATUM s.f. | | | | | | | | 2 | |
| NEW GENUS NEW SPECIES B | | | | | | | | 9 | |
| NEW GENUS NEW SPECIES C | | | | | | | | 12 | |
| OISTODUS INAEQUALIS s.f. | | | | 1 | 1 | 1 | 1 | | |
| OISTODUS LANCEOLATUS s.l. | | | | | 4 | 3 | 3 | 5 | |
| OISTODUS PSEUDORAMIS s.f. | | | | | 2 | 2 | 2 | 1 | |
| OISTODUS n. sp. 1 Serpagli | | | | | 2 | 3 | 4 | 3 | |
| OISTODUS ? STRIOLATUS s.f. | | | | | | 1 | 3 | 3 | |
| OISTODUS ? sp. aff. O. ? sp. Serpagli | | | | | | 2 | 1 | | |
| PARACORDYLODUS GRACILIS | | | | | | | | 12 | |
| PAROISTODUS AMONEUS | 7 | 12 | 8 | 13 | 1 | | | | |
| PAROISTODUS PARALLELUS | | 4 | 5 | 7 | 12 | 10 | 7 | 21 | 3 |
| OEPIKODUS COMMUNIS s.l. | | | | | | 3 | | | |
| PROTOPANDERODUS sp. aff. P. ASYMMETRICUS | 2 | 3 | 4 | 2 | 3 | | | | |
| PROTOPANDERODUS ? sp. aff. P. TRICARINATUS | | 12 | 4 | 3 | 3 | | | | |
| PYGODUS sp. s.f. | | 1 | | | | | | 1 | |
| PGYODUS ? sp. s.f. | | | | | 1 | | | 1 | |
| TRIANGULODUS n. sp. A | | | | 8 | 12 | 16 | 5 | 5 | |
| SCANDODUS sp. aff. S. FLEXUOSUS | 8 | 4 | 7 | 6 | 5 | 2 | | | |
| SCOLOPODUS GRACILIS | 1 | 2 | 4 | 8 | 4 | 3 | 1 | 1 | |
| SCOLOPODUS sp. aff. S. QUADRAPLICATUS | 1 | 2 | 1 | 3 | 5 | 2 | 1 | | |
| SCOLOPODUS REX | | 2 | 2 | 9 | 15 | 7 | 7 | 4 | |
| STOLODUS sp. aff. S. STOLA | | | | | | | | 9 | |
| WALLISERODUS sp. aff. W. AUSTRALIS s.l. | | 4 | 3 | 31 | 16 | 15 | 10 | 10 | |
| WESTERGAARDODINA ? sp. 2 s.f. | | | | | | | | 1 | |

TABLE VI

| FORMATION: | BROKEN SKULL | | | | | | SUNBLOOD |
|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | 33.5 | 21.3 | 15.2 | 11.0 | 6.1 | 0 | - |
| DISTANCE ABOVE BASE IN METERS: | - | - | - | - | - | - | 70 |
| SAMPLE NUMBER: | D750 | D790 | D810 | D825 | D840 | D860 | HO |
| TAXA: | | | | | | | |
| CLAVOHAMULUS sp. s.f. | | | | | 2 | 1 | |
| DREPANODUS ARCUATUS s.l. | 2 | 2 | 7 | 3 | 1 | | |
| DREPANOISTODUS BASIOVALIS | | | 7 | 9 | 18 | 12 | 16 |
| DREPANOISTODUS CONULATUS ? | | 2 | 3 | 2 | | 7 | 6 |
| DREPANOISTODUS FORCEPS | | | 4 | 6 | 7 | 9 | 7 |
| EONEOPRIONIODUS ? spp. | | | | 3 | 3 | 3 | 1 |
| JUANOGNATHUS JAANUSSONI | | | 3 | 10 | 11 | 12 | - |
| JUANOGNATHUS VARIABILIS | | | 2 | 7 | 12 | 10 | 3 |
| NEW GENUS A n. sp. 1 Serpagli, 1974 | | | | 2 | 3 | 3 | 5 |
| NEW GENUS A Sweet et al., 1971 s.f. | | | | | | | 90 |
| NEW GENUS B Sweet et al., 1971 s.f. | | | | | | | 1 |
| OELANDODUS sp. | | | | | | | 18 |
| OEPIKODUS COMMUNIS s.l. | 1 | 4 | 3 | 8 | 4 | 13 | 8 |
| OISTODUS LANCEOLATUS | | 3 | 1 | 1 | 2 | | |
| OISTODUS SCALENOCARINATUS | | | | 1 | 2 | 2 | 3 |
| OISTODUS n. sp. 1 | | | | | | | 1 |
| PAROISTODUS PARALLELUS | | 3 | 11 | | 9 | 7 | 10 |
| PERIODON FLABELLUM | | | | | | | 7 |
| PRIONIODUS sp. 1. s.f. | | | | | | | 1 |
| PROTOPANDERODUS GRADATUS | | | | 2 | 2 | 6 | 8 |
| PROTOPANDERODUS cf. P. LEONARDII | | 7 | | 4 | 5 | 6 | |
| REUTTERODUS ANDINUS | | | | 1 | 1 | 2 | 2 |
| TRIANGULODUS ROBUSTUS | | 4 | 2 | 1 | 3 | 4 | 43 |
| TRICHONODELLA ? sp. | | | | | | | 1 |
| TRICHONODELLA sp. 1 | | | | | | | 1 |
| WALLISERODUS ? sp. s.f. | | | | | | 1 | |

TABLE VII

| FORMATION: | SUNBLOOD | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | 596.8 | 566.9 | 537.9 | 509.0 | 405.4 | 387.1 | 379.4 | 332.2 | 393.2 | 382.5 | 355.1 | 327.6 | 266.7 | |
| SAMPLE NUMBER: | G1137 | G1235 | G1330 | G1425 | G1765 | G1825 | G1850 | G2005 | E1030 | E1065 | E1155 | E1245 | E1445 | S290 |
| TAXA: | | | | | | | | | | | | | | |
| CORDYLODUS sp. aff. C. HORRIDUS | | | | | | | | | | | | | | 6 |
| DISTACODUS n. sp. A | | | | | 2 | 2 | 8 | | | | | | 3 | 6 |
| DREPANOISTODUS SUBERECTUS | 1 | 3 | | 7 | | | | 2 | 1 | | | | 7 | 8 |
| 'DREPANOISTODUS' ? spp. s.f. | | | | | | 5 | 5 | | | | | 1 | 1 | 1 |
| EONEOPRIONIODUS ? spp. s.f. | 2 | 2 | | | | | | | 2 | 1 | | | | |
| EVENCODUS sp. aff. E. SIBIRICUS | | | | | | | | | | | | | | 12 |
| HISTIODELLA SINUOSA s.f. | | | | | | | | | | | | | | 12 |
| LEPTOCHIROGNATHUS n. sp. A | | 1 | | 29 | | | | | | 1 | 21 | | | |
| MULTIOISTODUS SUBDENTATUS | 1 | 2 | | 38 | 8 | 18 | 18 | | 1 | 1 | 18 | | 30 | 25 |
| MULTIOISTODUS spp. | | 1 | | 3 | 3 | 15 | 14 | | | | 5 | | 8 | 2 |
| NEW GENUS NEW SPECIES D | | | | | | | | | | | | | | 25 |
| OISTODUS SCALENOCARINATUS | | | | 1 | 2 | 1 | 2 | | | | 1 | | | 1 |
| "OISTODUS" spp. s.f. | | | | | 2 | 3 | 4 | | | | | | | 7 |
| POLYCAULODUS spp. s.f. | | | | | | 2 | | | | | | | 2 | 7 |
| PTERACONTIODUS EXILIS ? s.f. | | | | | | | | | | | | | 2 | |
| PRIONIODUS sp. 2 s.f. | | | | | | | | | 1 | 1 | | | | |

TABLE VIII

| FORMATION: | SUNBLOOD | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | - | - | - | 420.6 | 379.7 | 379.6 | 344.4 | 336.8 | 251.4 | 281.9 | 231.6 |
| SAMPLE NUMBER: | B310 | B360 | B400 | P25 | P100 | P160 | P275 | P300 | E1495 | G2170 | G2335 |
| TAXA: | | | | | | | | | | | |
| DISTACODUS n. sp. A | 10 | 12 | 8 | | 1 | 3 | | 2 | | 2 | |
| DREPANOISTODUS SUBERECTUS | 3 | 8 | | 1 | 3 | 1 | | 6 | 6 | 2 | 6 |
| "EONEOPRIONIODUS" n. sp. A | 2 | 11 | 18 | 4 | 1 | 17 | 4 | 14 | | | |
| ERISMODUS n. sp. 1 s.f. | 2 | 1 | 2 | | 1 | 1 | 2 | 3 | | | |
| HISTIODELLA sp. A. Sweet *et al.*, 1971 | 1 | | | | | | | | | | |
| NEW GENUS C. Sweet *et al.*, 1971 s.f. | | | 1 | | | | | | | | |
| MULTIOISTODUS SUBDENTATUS ? | | 5 | | | | | | 7 | 4 | | 3 |
| "PHRAGMODUS" n. sp. A | 7 | 6 | 7 | 2 | 8 | 12 | 17 | 12 | 5 | 4 | 9 |

TABLE IX

| FORMATION: | SUNBLOOD | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | - | - | - | - | - | - | - | 268.2 | 213.3 | 207.2 | 84.7 | 66.4 | 61,0 | 199.6 | 91.4 |
| SAMPLE NUMBER: | B700 | B795 | B860 | B1005 | B1100 | B1295 | B1310 | P525 | P705 | P725 | P1127 | P1187 | P1205 | E1665 | G2795 |
| TAXA: | | | | | | | | | | | | | | | |
| BELODINA COMPRESSA | | | | | | | | 2 | | | | 6 | | | |
| CURTOGNATHUS TYPUS* s.l. | | | | 12 | 15 | 13 | 8 | 12 | 8 | | 27 | | | | |
| DREPANOISTODUS SUBERECTUS s.l. | 3 | 26 | 5 | 16 | 1 | 18 | 3 | 3 | 2 | 6 | 7 | 2 | 6 | 2 | 7 |
| ERISMODUS ? spp. s.f. | | | | | | | | 3 | 2 | 2 | | | | | |
| ERISMODUS spp. | | | | | | | | 4 | 9 | 12 | 14 | | | | 5 |
| OULODUS n. sp. A | 10 | 10 | 15 | 3 | 2 | | | | | | | | | | |
| PANDERODUS GRACILIS | | | | 2 | 1 | 1 | | 2 | | | | | | | |
| PHRAGMODUS FLEXUOSUS s.l. | 2 | 3 | | 58 | 35 | 42 | 26 | 28 | | 26 | 14 | | 21 | 4 | |
| PLECTODINA ACULEATA | 2 | 12 | 4 | 6 | 6 | 12 | 16 | 12 | | 8 | 15 | 1 | | 2 | 12 |
| "PTILOCONUS" ? STRACHANOGNATHOIDES | | | | | | | | 6 | 4 | 3 | 2 | | | | |
| RHIPIDOGNATHUS ? n. sp. A | | | | 5 | 3 | | | | | | | | | | |

* Also includes elements belonging to Polycaulodus bidentatus (also in Tables XI and XII).

TABLE X

| FORMATION: | EB | SB | ESBATAOTTINE | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | 155.4 | 70.0 | 170.7 | 160.0 | 155.4 | 150.9 | 144.8 | 140.2 | 135.6 | 196.6 | 184.4 | 172.2 | 164 | 143.2 |
| DISTANCE ABOVE BASE IN METERS: | 27.4 | - | 6.1 | 16.8 | 21.3 | 25.9 | 32.0 | 36.6 | 41.1 | 0 | 12.2 | 24.4 | 32.6 | 53.3 |
| SAMPLE NUMBER: | H820 | A100 | A75 | A110 | A125 | A140 | A160 | A175 | A190 | P1405 | P1445 | P1485 | P1512 | P1585 |
| TAXA: | | | | | | | | | | | | | | |
| APPALACHIGNATHUS DELICATULUS | 1 | 2 | | | | 1 | | 1 | 1 | 2 | | 3 | | 1 |
| BELODELLA ERECTA | 1 | | | 1 | | 1 | | 1 | 1 | | | 2 | | 1 |
| BELODINA COMPRESSA | 6 | | 1 | | 1 | | | | 1 | | | 12 | | 1 |
| CURTOGNATHUS TYPUS* s.l. | 2 | 34 | | | | | | | | 17 | | | | |
| CHIROGNATHUS MONODACTYLUS | | | | | | | | | | 24 | | | | |
| CHIROGNATHUS n. sp. 1 s.f. | | | | | | | | | | 1 | | | | |
| 'CYRTONIODUS' sp. 1 s.f. | | | | | | | | | 1 | | | | | |
| 'CYRTONIODUS' sp. 2 s.f. | | | | | | | | | 1 | | | | | |
| DREPANOISTODUS SUBERECTUS s.l. | 10 | 6 | 1 | 4 | 4 | | | 3 | 8 | 3 | | 3 | 2 | 4 |
| ERISMODUS spp. | | 27 | | | | | | | | 11 | | | | |
| "ERISMODUS" sp. A | | | | | 4 | | | 4 | 5 | | | 2 | 1 | |
| LEPTOCHIROGNATHUS QUADRATUS s.l. | | 71 | | | | | | | | | | | | |
| PANDERODUS GRACILIS | 8 | 3 | 1 | 2 | 8 | | 16 | | 12 | | 5 | 12 | | |
| PHRAGMODUS FLEXUOSUS SYMMETRICUS | 23 | 1 | | 32 | 28 | 8 | 6 | 8 | 48 | | | | 12 | 1 |
| PLECTODINA ACULEATA | 32 | 6 | | 7 | 12 | 3 | 8 | | 24 | 4 | 7 | | | |
| TRIANGULODUS n. sp. B | 2 | | 1 | | 2 | | | 1 | | | | | 3 | 2 |
| STAUFFERELLA FALCATA | | | | | 1 | | | | | | | | | 1 |
| STEREOCONUS sp. s.f. | | 14 | | | | | | | | 7 | | | | |

TABLE XI

| FORMATION: | ESBATAOTTINE | | | | | ? SUNBLOOD | | | EB | SB | SB | ESBATAOTTINE | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW TOP IN METERS: | 126.5 | 120.4 | 118.3 | 82.3 | 61.0 | - | - | - | 47.2 | 147.8 | 76.2 | 131.1 | 94.5 | 129.5 | 117.3 | 97.5 | 56.4 | 36.6 |
| DISTANCE ABOVE BASE IN METERS: | 50.3 | 56.4 | 58.5 | 94.5 | 170.7 | - | - | - | 30.5 | - | 157.0 | 51.8 | 88.4 | 67.1 | 79.2 | 99.1 | 140.2 | 160.0 |
| SAMPLE NUMBER: | A220 | A240 | A247 | A365 | A615 | B1370 | B1450 | B1600 | G3195 | E1835 | D1375 | H900 | H1020 | P1625 | P1665 | P1730 | P1870 | P1930 |
| TAXA: | | | | | | | | | | | | | | | | | | |
| ACODUS MUTATUS | 1 | 1 | | | | | | | | | | | 2 | | 1 | 1 | | |
| APPALACHIGNATHUS DELICATULUS | | 6 | 1 | | | | | | 2 | | | | | 1 | 2 | 20 | | |
| BELODELLA ERECTA | | | 1 | | | | | | 2 | | | | | 2 | 1 | 3 | | |
| BELODINA COMPRESSA | 1 | | | | 3 | | | | 8 | | | 5 | | 6 | 12 | | | 3 |
| CURTOGNATHUS TYPUS* s.l. | | | | | | 7 | 8 | | | | | | | | | | | |
| DREPANOISTODUS SUBERECTUS s.l. | | 7 | | | | | | | 10 | 3 | | 2 | | 7 | 28 | 6 | 3 | 2 |
| ERISMODUS spp. | | | | | | 4 | 1 | | 4 | | | | | | 2 | 8 | | |
| OISTODUS NEVADENSIS s.f. | | | 1 | 1 | 2 | | 1 | | 4 | 1 | 1 | 2 | 8 | 2 | 8 | | | |
| PANDERODUS GRACILIS | 1 | | | 10 | 4 | | 3 | | 5 | | 6 | 8 | 24 | 11 | 12 | | 1 | 1 |
| PHRAGMODUS INFLEXUS | | | | | | | | | | 2 | | | 2 | | 3 | 1 | | |
| PHRAGMODUS n. sp. 1 s.f. | | | | | | | 4 | | | | | | | | | | | |
| PLECTODINA ACULEATA | 8 | 5 | | 14 | 17 | | 24 | 2 | 12 | | 16 | 7 | 12 | 7 | 98 | 8 | 5 | 5 |
| POLYPLACOGNATHUS RAMOSUS | | | | | | | | | | | | | | | | 1 | | |
| SCYPHIODUS sp. s.f. | | | | | | | | | | | | | | | | 1 | | |
| STEREOCONUS sp . s.f. | | | | | | | | | | | | | | 1 | | 8 | | |
| STAUFFERELLA FALCATA | | | | | | | | | | | | | | 1 | | 1 | | |
| STAUFFERELLA LINDSTROEMI | | | | | | | | | | | | | | | 1 | | | |
| TRIANGULODUS n. sp. B | | 12 | | | 2 | | 8 | | | | | | | 2 | 8 | 14 | | |

TABLE XII

| FORMATION: | WH | ? SUNBLOOD | | | SB | WHITTAKER | | | | | | | | | ESBATAOTTINE | | | WH |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE BELOW BASE IN METERS: | | | | | 47.24 | - | - | - | - | - | - | - | - | - | 16.8 | 9.1 | 6.3 | - |
| DISTANCE ABOVE BASE IN METERS: | 68.6 | - | - | - | 186.0 | 3.0 | 16.8 | 39.6 | 37.2 | 58.5 | 67.1 | 86.9 | 93.0 | 112.8 | 166.1 | 173.7 | 190.5 | 70.1 |
| SAMPLE NUMBER: | A860 | B1835 | B2000 | B2100 | D1470 | D1635 | E2375 | E2445 | E2475 | E2512 | E2540 | E2605 | E2625 | E2690 | H1275 | H1300 | P2030 | P2280 |
| TAXA: | | | | | | | | | | | | | | | | | | |
| ACODUS MUTATUS : | | | | | 1 | | | 1 | | | | | | | | | | |
| ANDRPHOGNATHUS sp. A ? | | | | | | | | 2 | | | | | | | | | | |
| BELODINA COMPRESSA | 12 | 6 | 1 | 1 | 1 | 3 | | 3 | 4 | 1 | 6 | 8 | 8 | 3 | | | | |
| BRYANTODINA ? ABRUPTA | | | | | | | | 1 | 1 | 1 | 2 | 2 | | | | | | |
| DREPANOISTODUS SUBERECTUS s.l. | | 1 | | 1 | 3 | 10 | 2 | 28 | 7 | 8 | 32 | 21 | 12 | 4 | | 2 | 2 | |
| PANDERODUS GRACILIS | 18 | 4 | 8 | 4 | | 3 | 21 | 1 | 4 | 2 | 4 | 12 | 11 | 12 | 8 | 3 | 1 | |
| PHRAGMODUS UNDATUS | 6 | | 1 | | 7 | | 6 | 364 | 72 | 285 | 315 | 475 | 454 | 2 | | | | |
| PLECTODINA ACULEATA | 15 | | 2 | | 3 | 7 | 8 | 24 | 13 | 24 | 45 | 31 | 68 | | 2 | 6 | | 3 |
| STAUFFERELLA FALCATA | | | | | | | | 1 | | 1 | 1 | | | | | | | |
| STAUFFERELLA LINDSTROEMI | | | | | | | | 1 | 1 | | | | | | | | | |

TABLE XIII

| FORMATION | WHITTAKER | | | | | | | | | | | | | | | | | | | | | | | | ? SUNBLOOD | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DISTANCE FROM TOP IN METERS: | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 204.2 | 97.5 | 67.1 | - | - | - | - | - | - |
| DISTANCE ABOVE THE BASE IN METERS: | 115.8 | 122.0 | 128.0 | 134.1 | 140.2 | 146.3 | 152.4 | 158.5 | 1300 | 154.0 | 158.5 | 196.6 | 0 | 30.5 | 158.5 | 176.8 | 206.2 | 58.0 | 67.1 | - | - | - | - | - | - | - | - | - |
| SAMPLE NUMBER: | E2700 | E2720 | E2740 | E2760 | E2780 | E2800 | E2820 | E2840 | D1668 | H1835 | H1850 | H1975 | H1720 | H1820 | Z1275 | Z1410 | Z1690 | M625 | M655 | J670 | J370 | J220 | C510 | C590 | C640 | B2220 | B2400 | B2600 |
| TAXA: | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ACODUS cf. A. SUMALTIPES s.f. | | | | | | | | | | | | | 1 | 3 | | | | | | | | | | | | | | |
| APHELOGNATHUS KIMMSWICKENSIS s.l. | 13 | | 16 | | 2 | | | | | | | | 4 | | | | 1 | | | | 4 | 2 | 5 | 11 | | 5 | 5 | |
| BELODINA COMPRESSA | | | 1 | | | 4 | | | 1 | 6 | 7 | | | | 1 | | | 12 | | 3 | 3 | | 1 | 1 | 4 | 6 | 3 | 2 |
| BRYANTODINA ? ABRUPTA | 2 | | 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| DREPANOISTODUS SUBERECTUS s.l. | 12 | | 14 | | | 4 | | 1 | | 1 | 3 | 1 | 4 | 3 | 4 | 4 | 1 | 2 | 1 | 3 | | 2 | | | | 1 | 4 | 3 |
| NEW GENUS NEW SPECIES 3 | | | 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| PANDERODUS GRACILIS s.l. | 1 | | 3 | 1 | | 14 | 1 | 1 | 8 | 8 | 3 | 2 | 24 | 5 | 7 | 2 | 3 | 16 | 8 | 12 | 10 | 12 | 12 | 13 | 12 | 7 | | 11 |
| PHRAGMODUS UNDATUS | 22 | 2 | 40 | | | | | | 1 | 4 | 3 | 4 | | | | 1 | | | | | | | | | | | | |
| PLECTODINA FURCATA s.l. | 50 | 2 | 33 | | 13 | | | 1 | 13 | 3 | 4 | 1 | 61 | 2 | 4 | 10 | 2 | 6 | 2 | 5 | 8 | 10 | 7 | 5 | 2 | 6 | | 3 |
| STAUFFERELLA FALCATA | 1 | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| STAUFFERELLA LINDSTROEMI | 1 | | 2 | | | | | | | | | | | | | | | | | | | | | | | | | |

TABLE XIV

# EXPLANATION OF PLATE 1

## CONODONTS, INCLUDING PARA AND (?)PROTO CONODONTS, FROM THE RABBITKETTLE FORMATION

Fig. 1. '*Hertzina*' ? sp. s.f. Lateral view, GSC50015, X60, K525.

Fig. 2. '*Prooneotodus*' *tenuis* (Müller) s.f. Lateral view, GSC50005, X60, K525.

Figs. 3-5. *Proconodontus* ? sp. s.f. Lateral view, GSC50850, GSC50851, GSC50852, X60 (all), K525 (all specimens).

Fig. 6. '*Furnishina*' ? sp. s.f. Lateral view, GSC50854, X60, K525.

Fig. 7. '*Westergaardodina*' ? sp. 1 s.f. Inner view, GSC50853, X60, K715.

Fig. 8. *Proconodontus notchpeakensis* Miller s.f. Lateral view, GSC50855, X60, K715.

Figs. 9, 10. *Proconodontus muelleri muelleri* Miller s.f. Lateral view, GSC50856, GSC50857, X60 (both), K715 (both specimens).

Fig. 11. New Genus New Species 1 s.f. Lateral view, GSC50858, X120, K715.

Figs. 12, 13. *Proconodontus* cf. *P. muelleri muelleri* Miller s.f. 12. Lateral view, GSC50002, X60, K880. 13. Lateral view, GSC50859, X60, K995.

Figs. 14, 21. *Proconodontus rotundatus* (Druce and Jones) s.f. 14. Lateral view, GSC50013, X60, K715. 21. Lateral view, GSC50014, X60, K715.

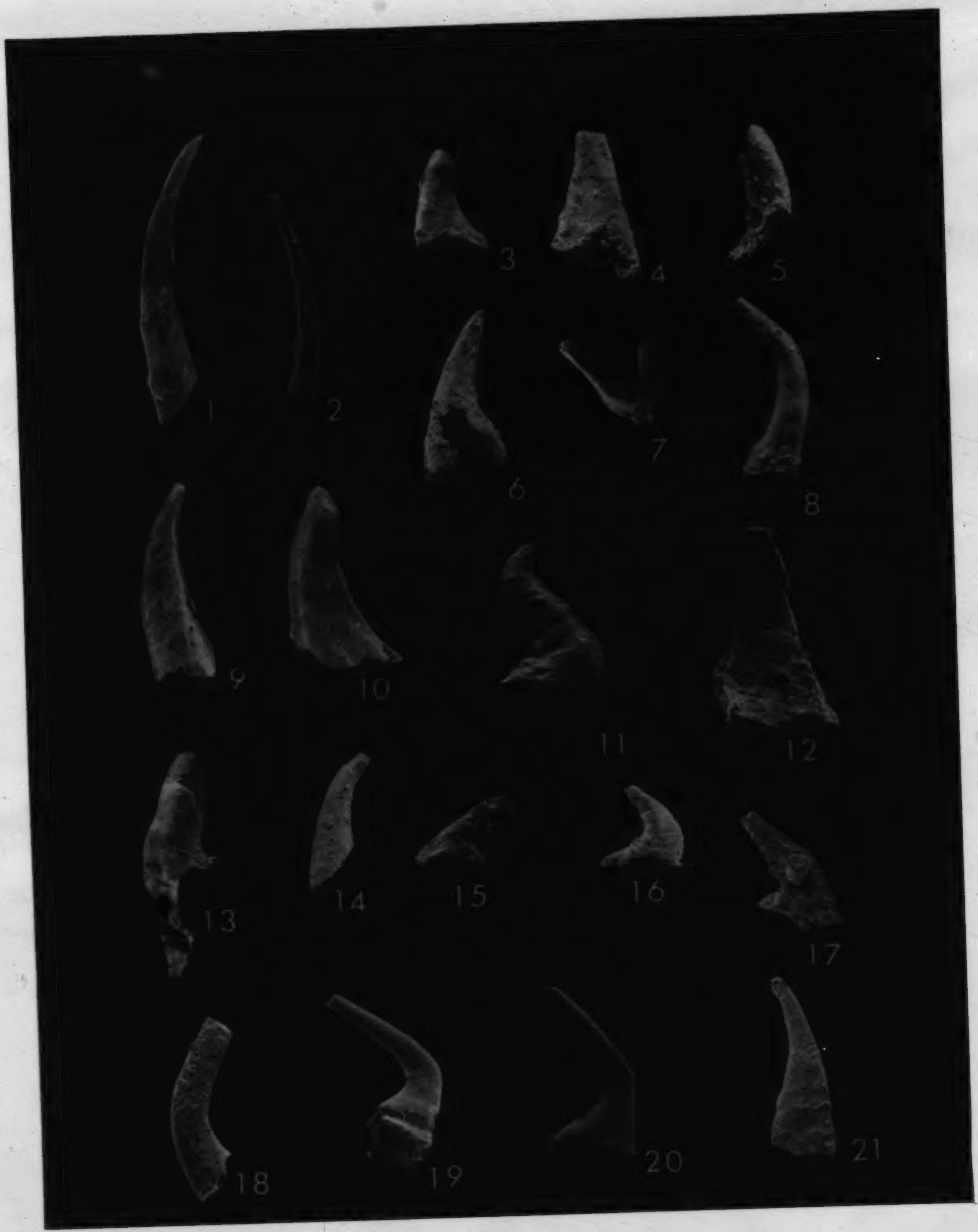
Fig. 15. "Paltodus" utahensis Miller ? s.f. Lateral view, GSC50860, X45, K715.

Fig. 16. Proconodontus ? primitivus (Druce and Jones) s.f. Lateral view, GSC50861, X45, K880.

Fig. 17. "Oistodus" cambricus Miller s.f. Lateral view, GSC50018, X45, K715.

Fig. 18. Drepanodus sp. ? s.f. Lateral view, GSC50862, X60, K995.

Figs. 19, 20. Oneotodus nakamuri Nogami s.f. 19,20. Lateral view, GSC50017, GSC50863, X60 (both), K715, K880.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## EXPLANATION OF PLATE 2

## CONODONTS FROM THE RABBITKETTLE AND THE ROAD RIVER FORMATIONS

Figs. 1, 3. Oneotodus n. sp. A s.f. 1,3. Lateral view, GSC50020, GSC50864, X45 (both), K995 (both specimens).

Fig. 2. Oneotodus erectus Druce and Jones s.f. Inner view, GSC50865, X45, K880.

Figs. 4, 5. Oneotodus gracilis (Furnish) s.f. 4. Inner lateral view, GSC50866, X60, K880. 5. Lateral view, GSC50867, X60, K995.

Figs. 6, 7, 9. Cordylodus proavus Müller s.f. 6,7,9. Lateral view, GSC50868, GSC50008, GSC50869, X60 (all), K880 (all specimens).

Fig. 8. Cordylodus sp. ? Müller s.f. Lateral view?, GSC50870, X60, K880.

Figs. 10, 11, 15, 16. Acodus n. sp. A. 10,11. Lateral views, acodiform and ramiform elements, GSC50028, GSC50871, X45 (both), K1900 (both specimens). 15,16. Lateral views of oistodiform elements, GSC50872 and GSC50029, X45 (both), K1900 (both specimens).

Figs. 12, 13, 18. Drepanoistodus forceps (Lindström). 12. Lateral view, homocurvatiform element, GSC50972, X45, K1900. 13. Lateral view, planus element, GSC50026, X45, K1900. 18. Lateral view, suberectiform element, GSC50024, X45, K1900.

Fig. 14. Protopanderodus rectus (Lindström). Lateral view, GSC50022, X45, K1900.

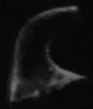
Fig. 17. Trichonodella longa minor Lindström s.f. Inner view, GSC50873, X60, K2020.

Fig. 19. Gothodus microdentatus Van Wamel s.f. Lateral view, GSC50971, X45, K2050.

Fig. 20. Oistodus lanceolatus Pander s.l. Lateral view, GSC50874, X45, K2020.

Fig. 21. Oepikodus evae (Lindström). Lateral view, oepikodiform element, GSC50216, X60, K2020.

Figs. 22, 23. Prioniodus elegans ? Pander. 22. Lateral view, gothodiform element, GSC50875, X60, K2020. 23. Lateral view, falodiform element, GSC50876, X60, K2020.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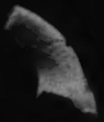
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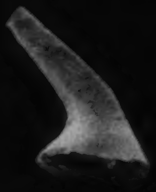
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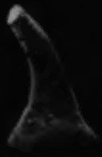
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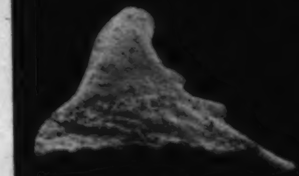
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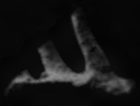
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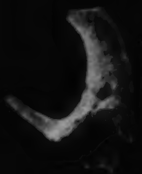
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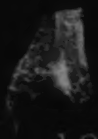
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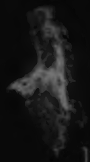
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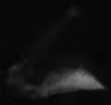
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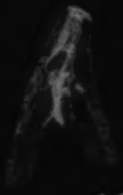
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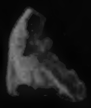
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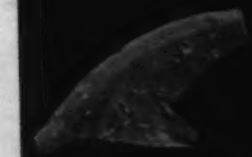
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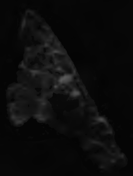
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## EXPLANATION OF PLATE 3

## CONODONTS FROM THE ROAD RIVER FORMATION

Figs. 1-3, 17. *Oepikodus evae* (Lindström). 1. Lateral view, oepikodiform element, GSC50877, X50, K2050. 2,3. Outer lateral view, prioniodiform elements, GSC50878, GSC50879, X50 (both), K2050 (both specimens). 17. Lateral view, oistodiform element, GSC50880, X50, K2050.

Fig. 4. *Acodus erectus* Pander. Posterior view, GSC50881, X50, K2020.

Figs. 5, 6. *Drepanoistodus basiovalis* ? (Sergeeva) s.l. Inner lateral views, oistodiform elements, GSC50203, GSC50884, X50 (both), K2375 (both specimens).

Fig. 7. *Paroistodus parallelus* ? (Pander). Lateral view, drepanodiform element, GSC50209, X45, K2375.

Fig. 8. *Scandodus* sp. s.f. Postero-lateral view, GSC50883, X30, K2375.

Fig. 9. *Cordylodus ramosus* Hadding. Lateral view, GSC50208, X30, K2375.

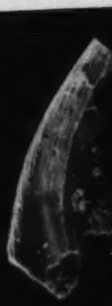
Fig. 10. *Keislognathus* sp. aff. *K. pyramidalis* (Sweet and Bergström) s.f. Lateral view, GSC50885, X30, K2145.

Fig. 11. *Leptochirognathus* n. sp. A. Inner view, GSC50211, X45, K2375.

Fig. 12. *Multioistodus subdentatus* Cullison. Lateral view, zygognathiform element, GSC50197, X45, K2375.

Figs. 13-16. New Genus New Species A. 13. Lateral view, oistodiform element?, GSC50886, X45, K2375. 14,15. Lateral views, roundya elements?, GSC50887, GSC50888, X45 (both), K2375 (both specimens). 16. Lateral view, cordylodiform element?, GSC50889, X45, K2375.

Fig. 18. *Acodus gladiatus* Lindström s.f. Lateral view, GSC50890, X60, K2090.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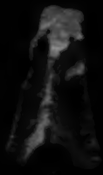
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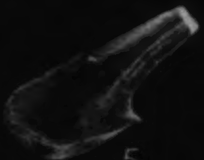
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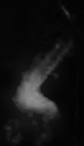
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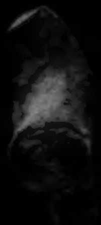
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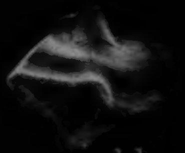
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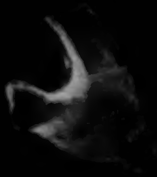
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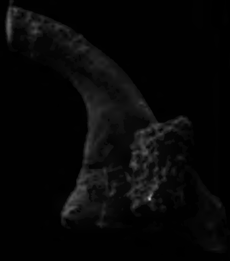
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## EXPLANATION OF PLATE 4

## CONODONTS FROM THE ROAD RIVER FORMATION

Figs. 1-3. *Oepikodus evae* (Lindström). 1. Lateral view, oepikodiform element, GSC50891, X50, K2050. 2. Lateral view, oistodiform element, GSC50892, X50, K2050. 3. Antero-lateral view, prioniodiform element, GSC50893, X50, K2050.

Figs. 4, 5. *Prioniodus crassulus* (Lindström). 4. Lateral view, GSC50220, X90, K2145. 5. Lateral view, GSC50221, X90, K2145.

Fig. 6. *Drepanodus arcuatus* Pander s.l. Lateral view, GSC50204, X60, K2375.

Fig. 7. *Cordylodus ramosus* Hadding. Lateral view, GSC50208, X50, K2375.

Fig. 8. *Oistodus venustus* Stauffer s.f. Lateral view, GSC50294, X50, K2375.

Fig. 9. *Eoplacognathus planus* (Sergeeva). Lateral view, ambalodiform element, GSC50193, X90, K2375.

Fig. 10. *Walliserodus ethingtoni* (Fåhraeus). Lateral view, GSC50924, X60, Loc. 5.

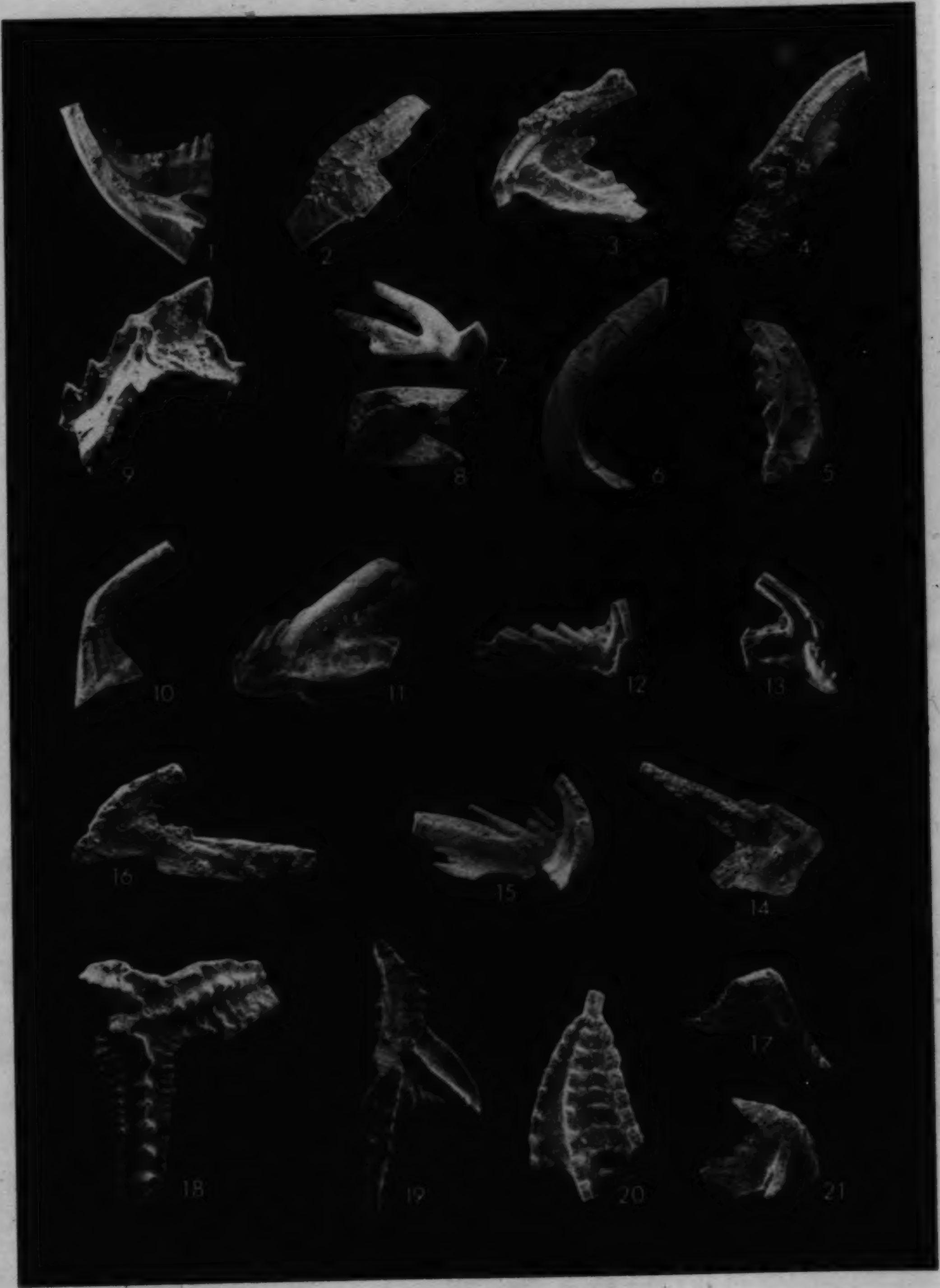
Figs. 11-13. *Periodon aculeatus* Hadding (early form).

11. Lateral view, falodiform element, GSC50223, X50, K2375.
12. Lateral view, periodontiform element, GSC50206, X50, K2375.
13. Lateral view, eoligonodiform element, GSC50207, X50, K2375.

Figs. 14-16. *Periodon aculeatus* Hadding. 14. Lateral view, falodiform element, GSC50235, X60. 15,16. Lateral views, periodontiform elements, GSC50234, GSC50233, X60. All specimens from Loc. 5.

Figs. 17, 20, 21. Pygodus serrus (Hadding). 17,21. Lateral views, haddingodiform elements, GSC50229, GSC50230, X60 (both), Loc. 5 (both specimens). 20. Upper view, pygodiform element, GSC50227, X60, Loc. 5.

Figs. 18, 19. Polyplacognathus friendsvillensis Bergström. 18. Oral view, polyplacognathiform element, GSC50224, X60. 19. Oral view, ambalodiform element, GSC50226, X60. Both specimens from Loc. 5.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## EXPLANATION OF PLATE 5

## CONODONTS FROM THE ROAD RIVER FORMATION

Figs. 1, 5, 7. *Eoplacognathus* n. sp. A ? 1. Oral view, ambalodiform element, GSC50194, X60, K2375. 5,7. Oral views, amorphognathiform elements, GSC50198, GSC50897, X120 and X45, K2375 (both specimens).

Figs. 2, 4. *Eoplacognathus planus* (Sergeeva). 2. Oral view, amorphognathiform element, GSC50197, X240, K2375. 4. Lateral view, ambalodiform element, GSC50732, X120, K2375.

Figs. 3, 6. *Rhodesognathus* n. sp. A ? 3. Oral view, amorphognathiform element, GSC50195, X120, K2375. 6. Oral view, ambalodiform element, GSC50898, X120, K2375.

Fig. 8. New Genus New Species 2. Lateral view, GSC50899, X60, K2375.

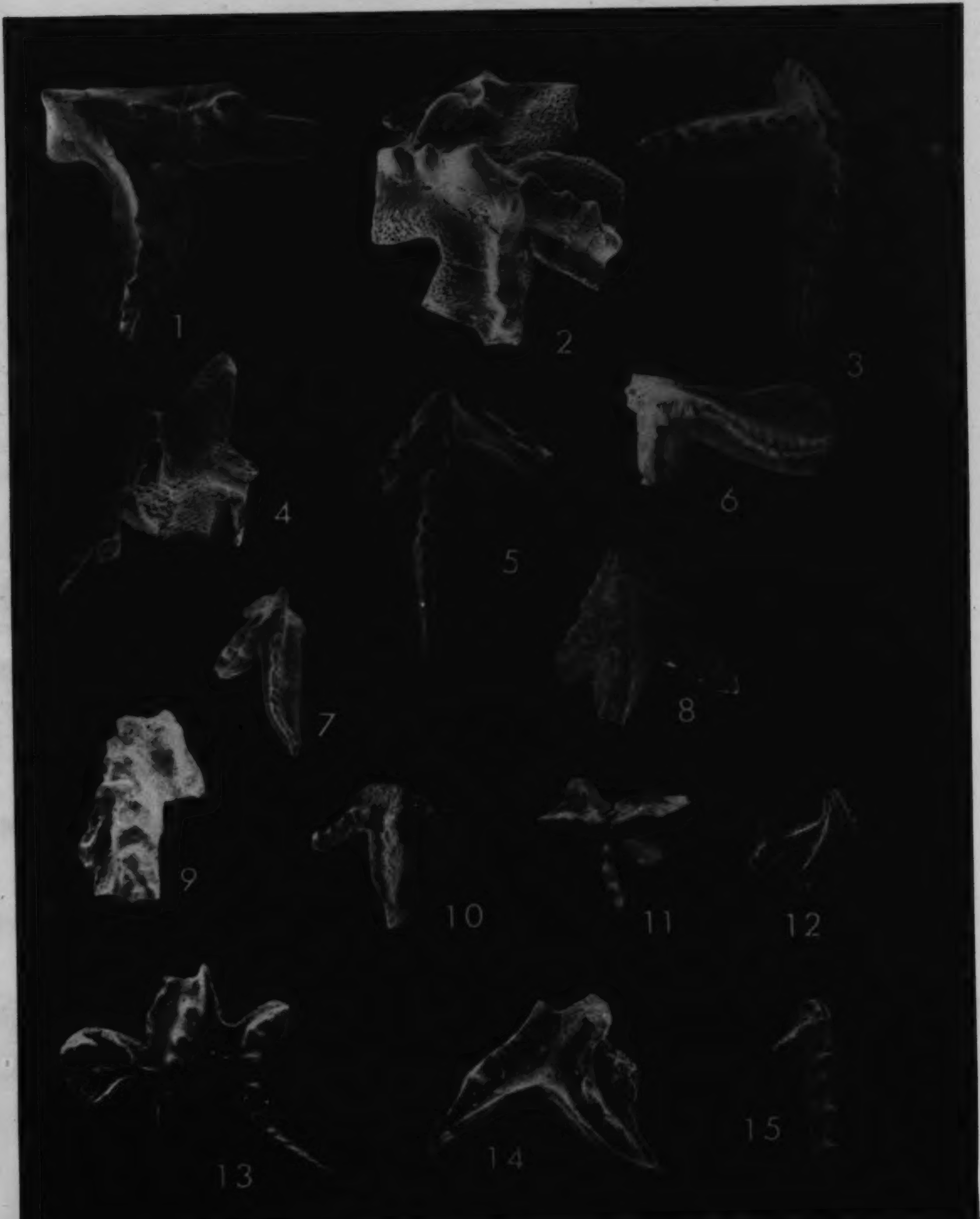
Fig. 9. *Pygodus* n. sp. 1 Uyeno and Barnes. Outer view, GSC50299, X60, K2375.

Fig. 10. *Polyplacognathus* sp. ? Oral view, GSC50900, X45, Loc. 5.

Figs. 11, 12. *Amorphognathus* sp. A ? 11. Oral view, amorphognathiform element, GSC50183, X60, E2445. 12. Lateral view, keislognathiform element, GSC50901, X60, E2445.

Figs. 13, 14. *Amorphognathus superbus* (Rhodes). 13. Oral view, amorphognathiform element, GSC50902, X45, Loc. 2. 14. Oro-lateral view, ambalodiform element, GSC50903, X45, Loc. 2.

Fig. 15. *Polyplacognathus friendsvillensis* Bergström. Oral view, part of polyplacognathiform element, GSC50904, X45, Loc. 5.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## EXPLANATION OF PLATE 6

## CONODONTS FROM THE ROAD RIVER FORMATION

Figs. 1-3. Phragmodus n. sp. B. 1,2. Lateral views, 'phragmodiform' elements, GSC50905, GSC50239, X60 (both), Loc. 5 (both specimens). 3. Lateral view, cyrtoniodiform element, GSC50240, X60, Loc. 5.

Figs. 4-6, 9. Periodon grandis (Ethington). 4,9. Lateral view, ozarkodiniform element, GSC50906, GSC50907, X60 (both), Loc. 2 (both specimens). 5. Lateral view, periodontiform element, GSC50908, X60, Loc. 2. 6. Lateral view, falodiform element, GSC50909, X45, Loc. 2.

Fig. 7. Chirognathus ? sp. s.f. Inner view, GSC50910, X45, Loc. 5.

Fig. 8. Drepanoistodus basiovalis (Sergeeva) s.l. Lateral view, oistodiform element, GSC50911, X60, Loc. 5.

Fig. 10. Belodina monitorensis marginata Ethington and Schumacher. Lateral view, belodiniform element, GSC50238, X60, Loc. 5.

Fig. 11. Periodon aculeatus Hadding. Inner view, ozarkodiniform element, GSC50912, X45, Loc. 5.

Fig. 12. Periodon aculeatus Hadding (early form). Inner view, ozarkodiniform element, GSC50913, X45, K2375.

Figs. 13-15. Belodella sp. aff. B. n. sp. Barnes and Poplawski. 13,14,15. Lateral views, GSC50237, GSC50236, GSC50914, X45 (all), Loc. 5 (all specimens).

Fig. 16. Strachanognathus parvus Rhodes s.f. Lateral view, GSC50915, X45, Loc. 5.

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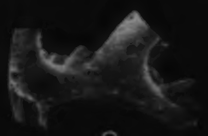
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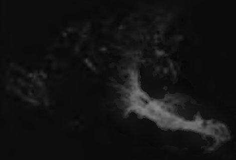
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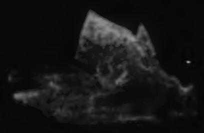
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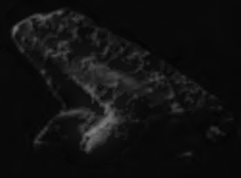
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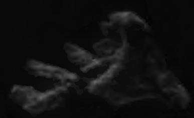
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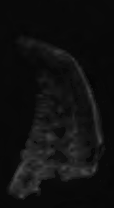
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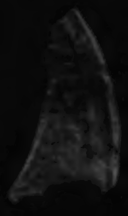
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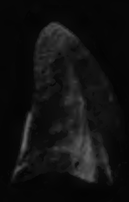
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# EXPLANATION OF PLATE 7

## CONODONTS FROM THE ROAD RIVER FORMATION

Figs. 1-4, 15. *Protopanderodus cooperi* (Sweet and Bergström). 1-4. Lateral views, GSC50916, GSC50200, GSC50917, GSC50201, X60 (all), K2375 (all specimens). 15. Lateral view, GSC50244, X45, Loc. 5.

Fig. 5. *Walliserodus ethingtoni* (Fåhraeus). Lateral view, GSC50925, X45, Loc. 5.

Figs. 6, 9. *Drepanodus arcuatus* ? Pander s.l. 6. Lateral view, pipaform element?, GSC50243, X45, Loc. 5. 9. Lateral view, drepanodiform element, GSC50922, X45, Loc. 5.

Figs. 7, 11, 13. *Drepanoistodus forceps* (Lindström) ? 7. Lateral view, drepanodiform (?) element, GSC50923, X60, Loc. 5. 11,13. Lateral view, oistodiform elements (?), GSC50920, GSC50921, X45 (both), Loc. 5. (both specimens).

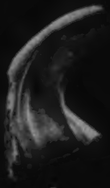
Fig. 8. *Acontiodus robustus* Hadding s.f. Lateral view, GSC50918, X45, Loc. 5.

Fig. 10. *Paroistodus parallelus* ? Pander s.l. Lateral view, oistodiform element, GSC50919, X60, Loc. 5.

Fig. 12. *Belodina moniterensis marginata* Ethington and Schumacher s.f. Lateral view, eobelodiniform element, GSC50242, X45, Loc. 5.

Fig. 14. *Protopanderodus insculptus* (Branson and Mehl). Lateral view, GSC50943, X45, Loc. 5.

Figs. 16, 17. *Panderodus gracilis* (Branson and Mehl). Lateral views, GSC50245, GSC50246, X60 (both), Loc. 5 (both specimens).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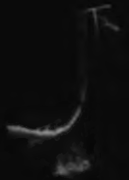
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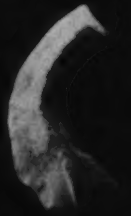
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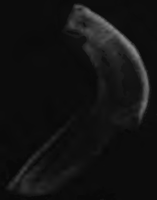
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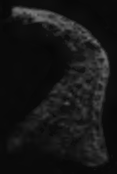
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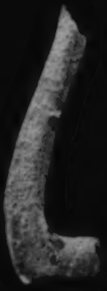
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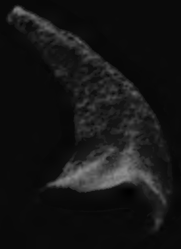
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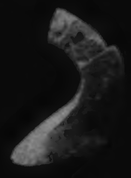
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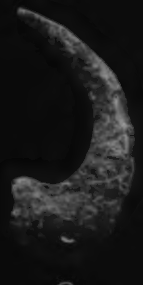
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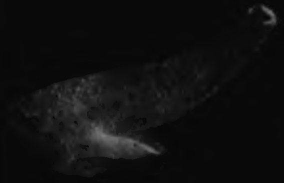
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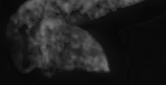
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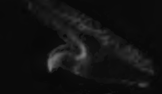
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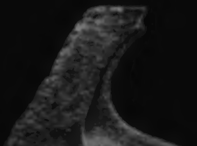
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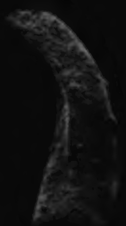
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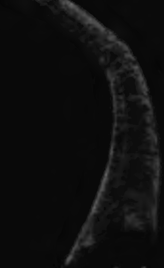
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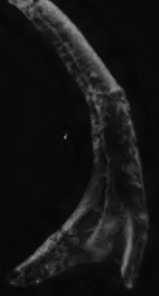
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# EXPLANATION OF PLATE 8

## LATE CANADIAN CONODONTS FROM THE BROKEN SKULL FORMATION

Fig. 1. Pygodus sp. s.f. Oral view, GSC50048, X45, D233.

Fig. 2. Pygodus ? sp. s.f. Lateral view, GSC50049, X45, D420.

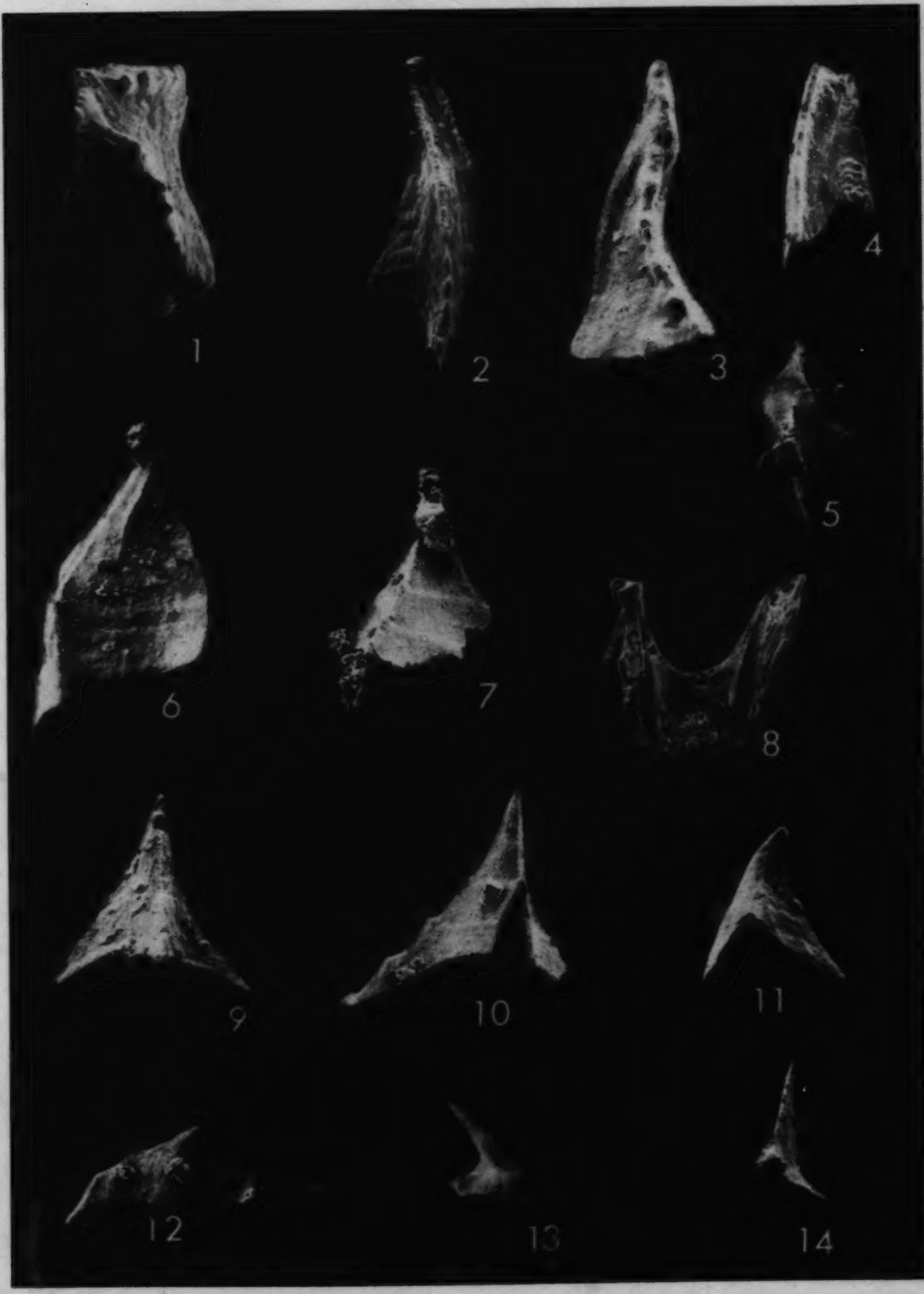
Fig. 3. Ambalodus ? sp. 1. Oral view, ambalodiform element?, GSC50248, X45, D555.

Figs. 4, 6, 7, 11. New Genus New Species B. 4. Lateral view, acontiodiform? element, GSC50249, X45, D555. 6,7. Lateral views, coelocerodontiform? and coelocerodontiform (1) elements, GSC50250, GSC50251, X60 (both), D555 (both specimens). 11. Lateral view, coelocerodontiform (2) element, GSC50252, X45, D555.

Fig. 5. Ambalodus ? sp. s.f. Oral view, amorphognathiform element?, GSC50247, X45, D555.

Fig. 8. 'Westergaardodina' ? sp. 2 s.f. Posterior-side view, GSC50253, X60, D555.

Figs. 9, 10, 12-14. New Genus New Species C. 9,10,14. Posterolateral views, 'serratus' elements, GSC50254, GSC50255, GSC50256, X45 (all), D555 (all specimens). 12,13. Lateral views, 'planus' elements, GSC50257, GSC50258, X45 (both), D555 (both specimens).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## EXPLANATION OF PLATE 9

## LATE CANADIAN CONODONTS FROM THE BROKEN SKULL FORMATION

Figs. 1, 2. Coelocerodontus n. sp. A. 1. Lateral view, open element, GSC50259, X60, D288. 2. Lateral view, compressed element, GSC50260, X60, D288.

Fig. 3. Drepanodus sp. aff. D. sp. Sweet and Bergström 1962 s.f. Lateral view, GSC50261, X60, D288.

Fig. 4. Drepanodus sp. s.f. Lateral view, GSC50045, X60, D288.

Figs. 5, 6. Scandodus sp. aff. S. flexuosus Barnes and Poplawski 5. Lateral view, GSC50262, X45, D288. 6. Lateral view, GSC50263, X45, D288.

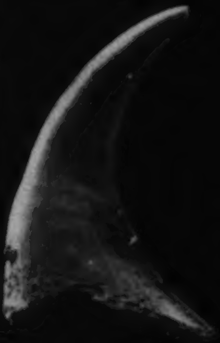
Figs. 7,8, 11-13. Triangulodus n. sp. A. 7. Lateral view, erect scandodiform element, GSC50266, X60, D375. 8. Lateral view, roundya element, GSC50267, X45, D375. 11. Lateral view, paltodiform element, GSC50268, X45, D375. 12. Lateral view, drepanodiform element, GSC50269, X45, D375. 13. Lateral view, acodiform element, GSC50055, X45, D375.

Figs. 9, 10, 14. Drepanoistodus conulatus (Lindström). 9. Lateral view, scandodiform element, GSC50054, X45, D375. 10. Inner lateral views, suberectiform element, GSC50264, X45, D375. 14. Lateral view, drepanodiform element, GSC50265, X45, D375.

Figs. 15, 19, 20. Protopanderodus sp. aff. P. asymmetricus Barnes and Poplawski. 15,19. Posterior views, GSC50271, GSC50272, X45 (both), D375 (both specimens). 20. Lateral view, GSC50273, X45, D375.

Figs. 16-18. Scolopodus rex Lindström sensu Serpagli, 1974.

Lateral views, GSC50046, GSC50047, GSC50270, X45 (all), D420 (all specimens).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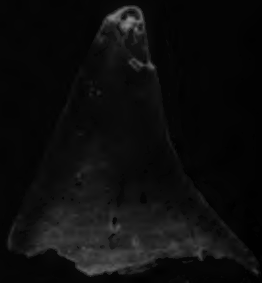
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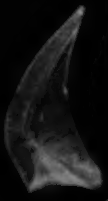
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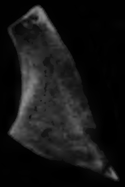
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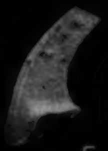
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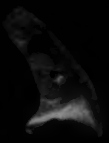
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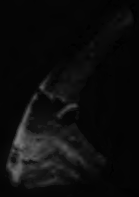
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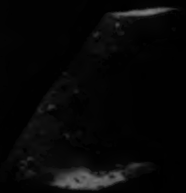
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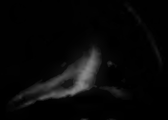
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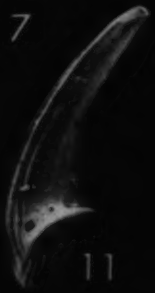
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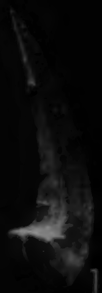
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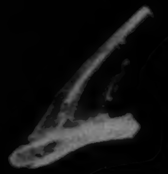
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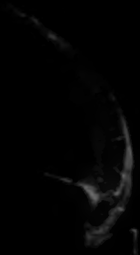
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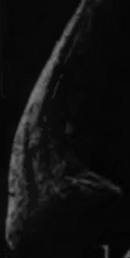
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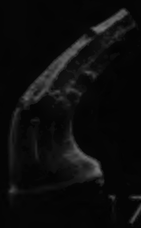
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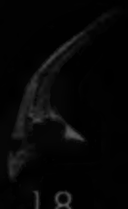
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## EXPLANATION OF PLATE 10

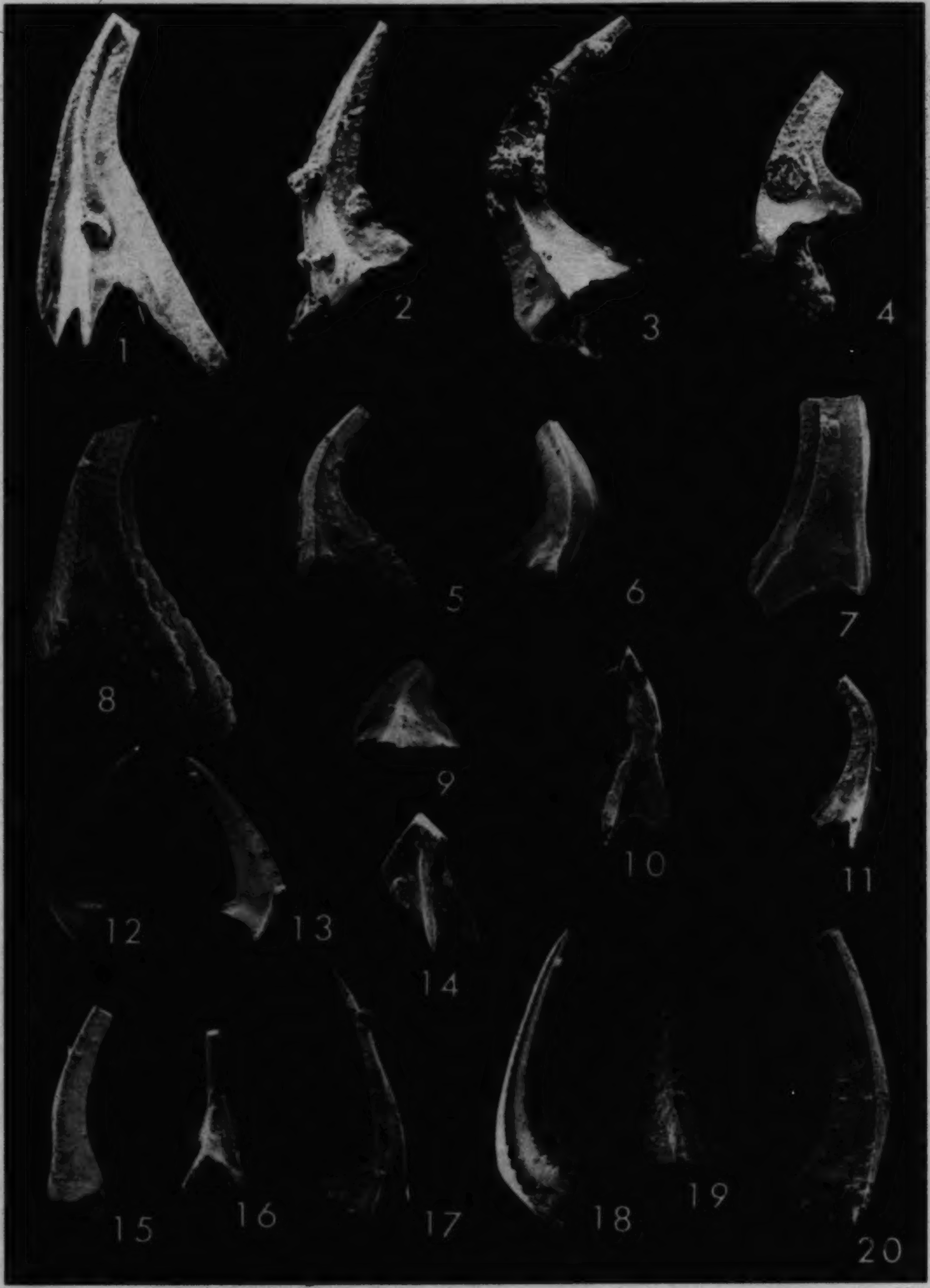
## LATE CANADIAN CONODONTS FROM THE BROKEN SKULL FORMATION

Figs. 1-4. Stolodus sp. aff. S. stola (Lindström). 1-3. Lateral views, distacodiform elements, GSC50274, GSC50275, GSC50276, X60 (all), D555 (all specimens). 4. Lateral view, acodiform (?) element, GSC50277, X45, D555.

Figs. 5-10. Acodus deltatus deltatus Lindström. 5-8. Lateral views, ramiform elements, GSC50278, GSC50279, GSC50280, GSC50281, X45 X45, X45, X90, D420 (all specimens). 9. Lateral view, prioniodiform element, GSC50282, X45, D420. 10. Lateral view, trapezognathiform ? element, GSC50283, X45, D420.

Figs. 11, 14-20. Walliserodus sp. aff. W. australis Serpagli. 11,15-17,20. Lateral views of three costate elements, GSC50285, GSC50286, GSC50287, GSC50288, GSC50289, X45 (all), D375 (all specimens). 14,19. Lateral views of four costate elements, GSC50290, GSC50291, X45 (both), D420 (both specimens). 18. Lateral view of five costate element, GSC50057, X45, D420.

Figs. 12, 13. Acodus sweeti (Serpagli). Lateral views, GSC50056, GSC50284, X45 (both), D420 (both specimens).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## EXPLANATION OF PLATE 11

## LATE CANADIAN CONODONTS FROM THE BROKEN SKULL FORMATION

Figs. 1-11, 16, 17. Drepanodus arcuatus Pander. 1. Lateral view, arcuatiform element, GSC50292, X60, D420. 2,3. Lateral views, pipaform(?) elements, GSC50298, GSC50299, X45 (both), D485 (both specimens). 4,8,9,16,17. Lateral views, arcuatiform elements, GSC50293, GSC50294, GSC50295, GSC50296, GSC50297, X45 (all), D485 (all specimens). 5,6. Lateral views, graciliform elements, GSC50300, GSC50301, X45 (both), D485 (both specimens). 7. Lateral view, sculponeaform element, GSC50302, X45, D375. 10,11. Lateral views, ulrichodiniform (?) elements, GSC50303, GSC50304, X45 (both), D485 (both specimens).

Figs. 12, 13. Drepanoistodus forceps (Lindström). 12. Lateral view, homocurvatiform element, GSC50305, X45, D420. 13. Lateral view, suberectiform element, GSC50306, X45, D420.

Figs. 14, 15. Scolopodus gracilis Ethington and Clark. Lateral views, GSC50307, GSC50035, X45 (both), D375 (both specimens).

Figs. 18, 19. Protopanderodus ? sp. aff. P. ? tricarinatus Barnes and Poplawski. Posterior views, GSC50037, GSC 50036, X45 (both), D375 (both specimens).

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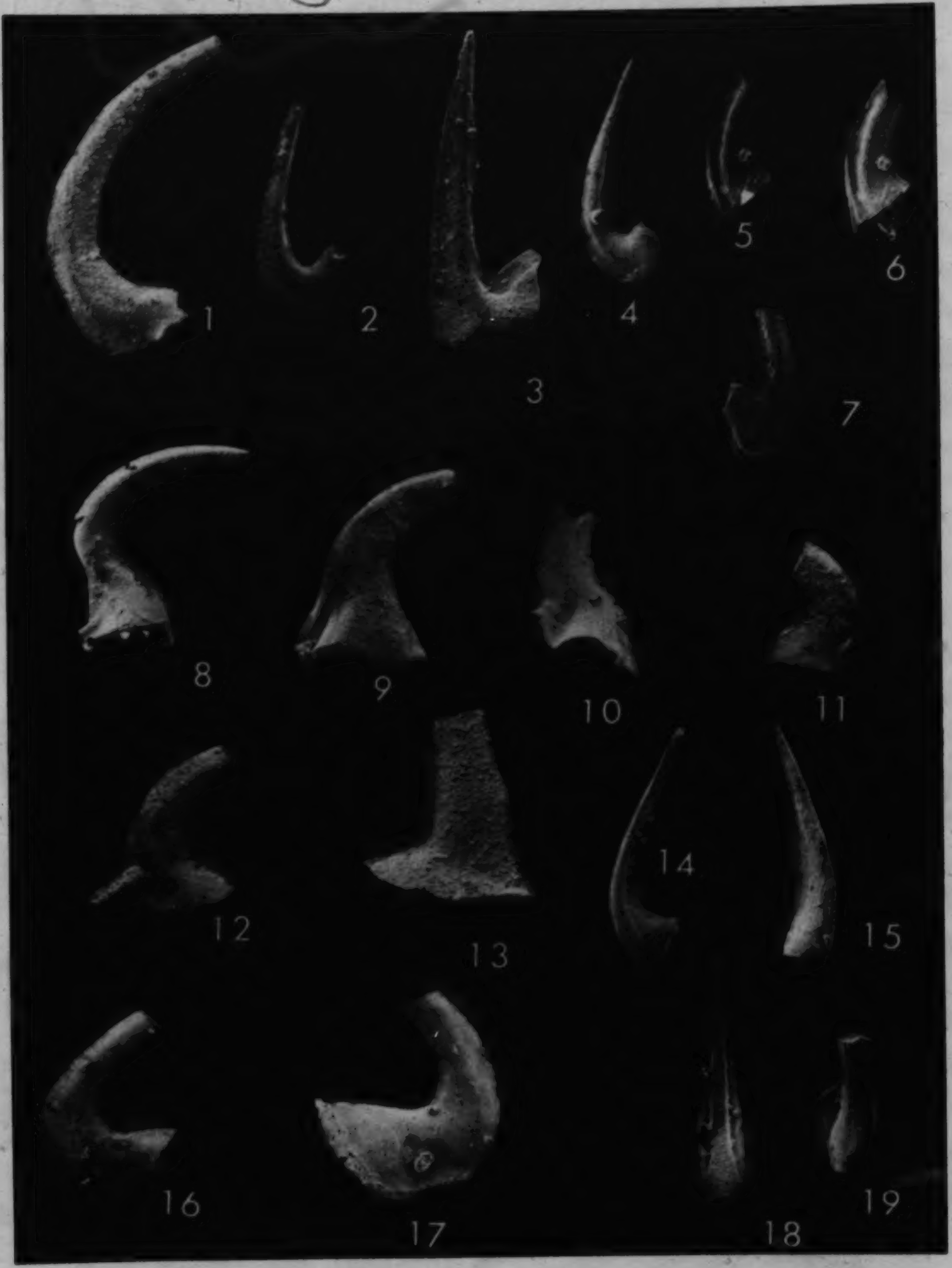
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## EXPLANATION OF PLATE 12

## LATE CANADIAN CONODONTS FROM THE BROKEN SKULL FORMATION

Figs. 1-3. *Oistodus lanceolatus* Pander s.l. 1. Lateral view, oistodiform element, GSC50040, X45, D450. 2. Lateral view, triangulariform element, GSC50039, X45, D450. 3. Lateral view, deltaform element, GSC50042, X45, D450.

Fig. 4. *Oistodus* ? sp. aff. *O.* ? sp. Serpagli, s.f. 1974. Lateral view, GSC50808, X45, D450.

Figs. 5, 6. *Oistodus* ? *striolatus* Serpagli. Lateral views, GSC50309, GSC50310, X45 (both), D485 (both specimens).

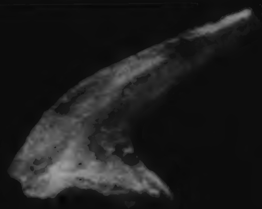
Figs. 7-10. *Oistodus* cf. *O.* n. sp. 1 Serpagli. Lateral views, GSC50311, GSC50312, GSC50313, GSC50314, X45 (all), D485 (all specimens).

Fig. 11. *Oistodus inaequalis* Lindström s.f. Lateral view, GSC50315, X30, D375.

Figs. 12, 13. *Oistodus pseudoramis* Serpagli s.f. Lateral views, GSC50316, GSC50317, X45 (both), D450 (both specimens).

Fig. 14. *Paracordylodus gracilis* Lindström. Lateral view, GSC50318, X45, D485.

Fig. 15. *Acodus deltatus deltatus* Lindström. Lateral view, oistodiform element, GSC50319, X45, D555.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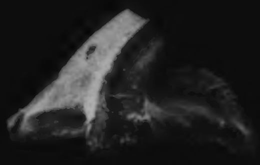
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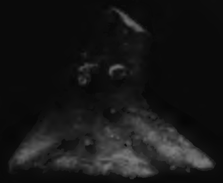
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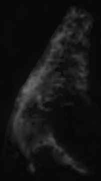
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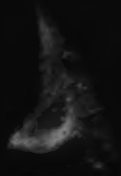
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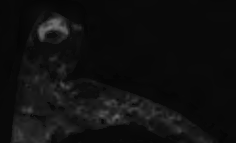
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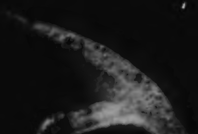
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## EXPLANATION OF PLATE 13

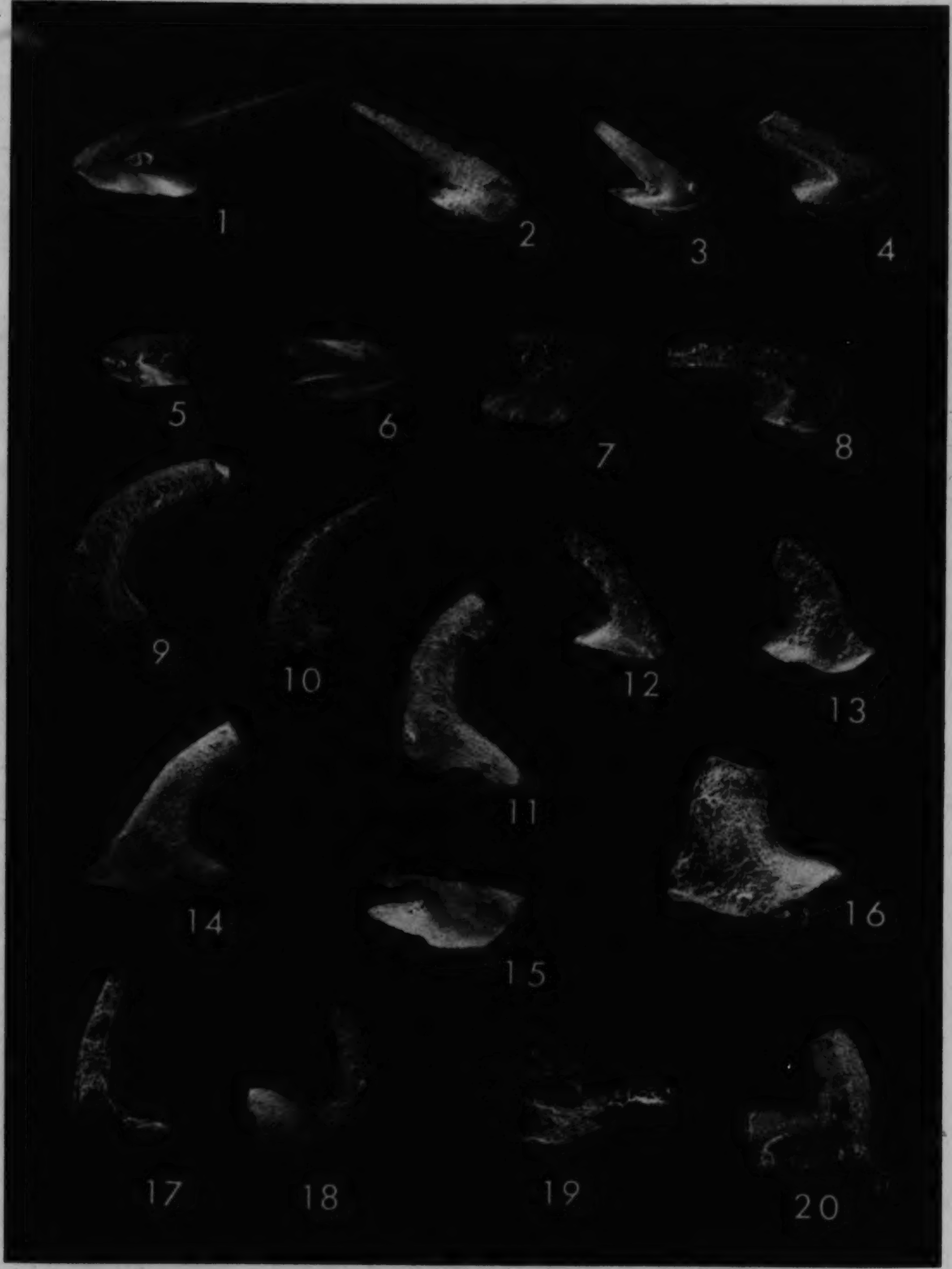
## LATE CANADIAN CONODONTS FROM THE BROKEN SKULL FORMATION

Figs. 1-3. Paroistodus amoenus (Lindström). 1. Lateral view, oistodiform element, GSC50034, X45, D215. 2,3. Lateral views, oistodiform elements, GSC50320, GSC50321, X30 (both), D215 (both specimens).

Figs. 4, 9, 10, 12-16. Drepanoistodus basiovalis (Sergeeva) s.l. 4. Lateral view, oistodiform element, GSC50322, X45, D840. 9,10,12-14,16. Lateral views, drepanodiform elements, GSC50341, GSC50342, GSC50343, GSC50344, GSC50345, GSC50346, X45 (all), D840 (all specimens). 15. Lateral view, oistodiform element, GSC50347, X45, D840.

Figs. 5, 6, 19(?). Drepanoistodus forceps (Lindström) s.l. Lateral views, oistodiform elements, GSC50339, GSC50340, GSC50335, X45, X60, X45, D420, D555, D860 respectively.

Figs. 7, 8, 11, 17, 18, 20. Paroistodus parallelus (Pander) s.l. 7,8. Lateral views, oistodiform elements, GSC50333, GSC50334, X45 (both), D485 and D555. 11,17,18,20. Lateral views, drepanodiform elements, GSC50721, GSC50336, GSC50337, GSC50338, X45 (all), D840, D555, D555 and D860 respectively.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## EXPLANATION OF PLATE 14

## LATE CANADIAN TO EARLY WHITEROCKIAN CONODONTS FROM THE BROKEN SKULL AND THE SUNBLOOD FORMATIONS

Figs. 1-13. *Oepikodus communis* (Ethington and Clark) s.l. 1,5,6,8,10,11. Lateral views, oepikodiform elements, GSC50063, GSC50347, GSC50348, GSC50062, GSC50349, GSC50350, X45 (all), D450, HO, D860, HO, D860, D860 respectively. 2,4,9,12,13. Lateral views, prioniodiniform elements, GSC50066, GSC50351, GSC50352, GSC50353, GSC50061, X45 (all), HO, D860, D860, G1137(?), HO respectively. 3,7. Lateral view, oistodiform elements, GSC50063, GSC50354, X45 (both), HO and D860 respectively.

Figs. 14, 15, 18. *Periodon flabellum* (Lindström) 14,18. Lateral views, periodontiform elements, GSC50357, GSC50358, X45 (both), HO (both specimens). 15. Inner lateral view, ozarkodiniform element, GSC50359, X60, HO.

Figs. 16, 19. *Oelandodus* sp. Lateral views, elongatiform elements, GSC50355, GSC50356, X45 (both), HO (both specimens).

Fig. 17. *Trichonodella* sp. 1 s.f. Inner view, GSC50084, X45, HO.

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# EXPLANATION OF PLATE 15

## LATE CANADIAN TO EARLY WHITEROCKIAN CONODONTS FROM THE BROKEN SKULL AND THE SUNBLOOD FORMATIONS

Figs. 1-4, 6, 8, 9. Triangulodus robustus (Serpagli). 1. Lateral view, drepanodiform element, GSC50360, X60, HO. 2,3. Lateral views, scandodiform elements, GSC50079, GSC50080, X60 (both), HO (both specimens). 4. Lateral view, erect scandodiform element, GSC50361, X60, HO. 6. Lateral view, oistodiform (?) element, GSC50362, X60, HO. 8,9?. Inner views, acontiodiform elements, GSC50363, GSC50364, X60 (both), HO (both specimens).

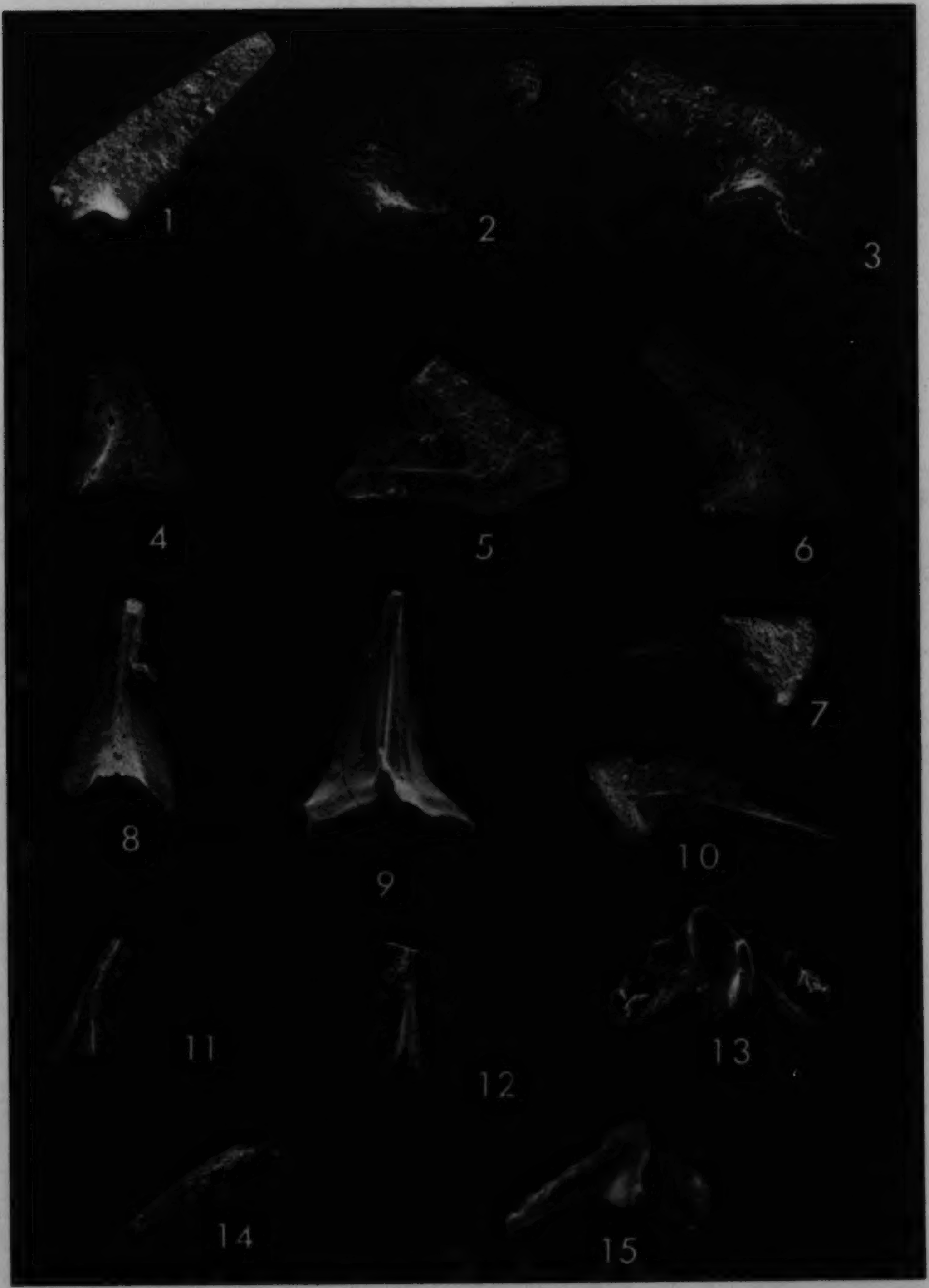
Figs. 5, 7, 10. New Genus A Sweet et al., 1971. 5. Lateral view, oistodiform element, GSC50365, X60, HO. 7,10. Lateral view, ramiform elements, GSC50366, GSC50075, X45 (both), HO (both specimens).

Figs. 11, 14. Oelandodus sp. 11. Lateral view, triangulariform element, GSC50367, X45, HO. 14. Outer view, oistodiform element, GSC50368, X45, HO.

Fig. 12. Trichonodella ? sp. s.f. Inner view, GSC50086, X45, HO.

Fig. 13. Prioniodus sp. 2 s.f. Outer lateral view, GSC50087, X45, E1030.

Fig. 15. Prioniodus sp. 1 s.f. Outer lateral view, GSC50089, X45, HO.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# EXPLANATION OF PLATE 16

## LATE CANADIAN TO EARLY WHITEROCKIAN CONODONTS FROM THE BROKEN SKULL AND THE SUNBLOOD FORMATIONS

Figs. 1-3. *Oistodus scalenocarinatus* Mound s.l. 1. Inner lateral view, GSC50369, X60, HO. 2,3. Outer lateral view, GSC50370, GSC50371, X60 (both), S290, D860.

Fig. 4. New Genus B n. sp.s.f. Barnes, 1977. Lateral view, GSC50378, X60, HO.

Fig. 5. *Clavohamulus* n. sp. 1 s.f. Oral view, GSC50372, X60, D860.

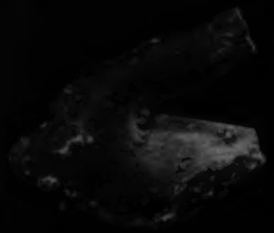
Fig. 6. *Oistodus* n. sp. 1 s.f. Inner lateral view, GSC50373, X60, D860.

Figs. 7, 8, 12. *Reutterodus andinus* Serpagli. 7,8. Inner lateral views, GSC50374, GSC50375, X60 (both), D860 (both specimens).
12. Inner lateral view, unibranched (?) element, GSC50377, X45, G1235.

Figs. 9, 11?. New Genus A n. sp. 1 Serpagli, 1974. 9. Lateral view, GSC50378, X60, D860. 11. Inner lateral view, GSC50376, X45, HO.

Fig. 10. *Walliserodus* ? sp. s.f. Lateral view, four costate elements, GSC50379, X60, D860.

Fig. 13. "*Scolopodus*" sp. s.f. Lateral view, GSC50380, X60, D615.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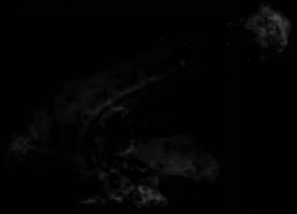
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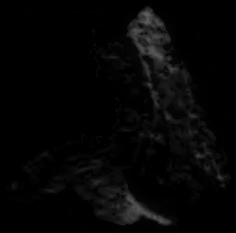
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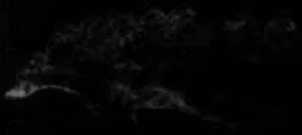
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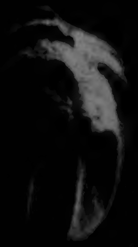
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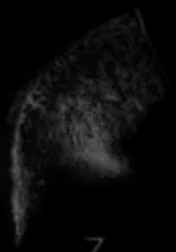
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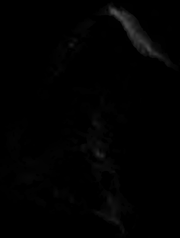
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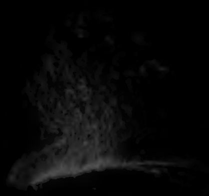
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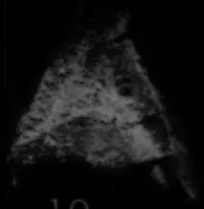
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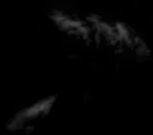
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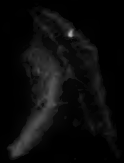
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## EXPLANATION OF PLATE 17

## LATE CANADIAN TO EARLY WHITEROCKIAN CONODONTS FROM THE BROKEN SKULL AND THE SUNBLOOD FORMATIONS

Figs. 1, 2. *Scolopodus* sp. aff. *S. quadraplicatatus* Branson and Mehl. Lateral views, GSC50381, GSC50382, X60 (both), D420 (both specimens).

Figs. 3-5. *Protopanderodus* cf. *P. leonardii* Serpagli. Lateral views, GSC50383, GSC50384, GSC50385, X45 (all), D840 (all specimens).

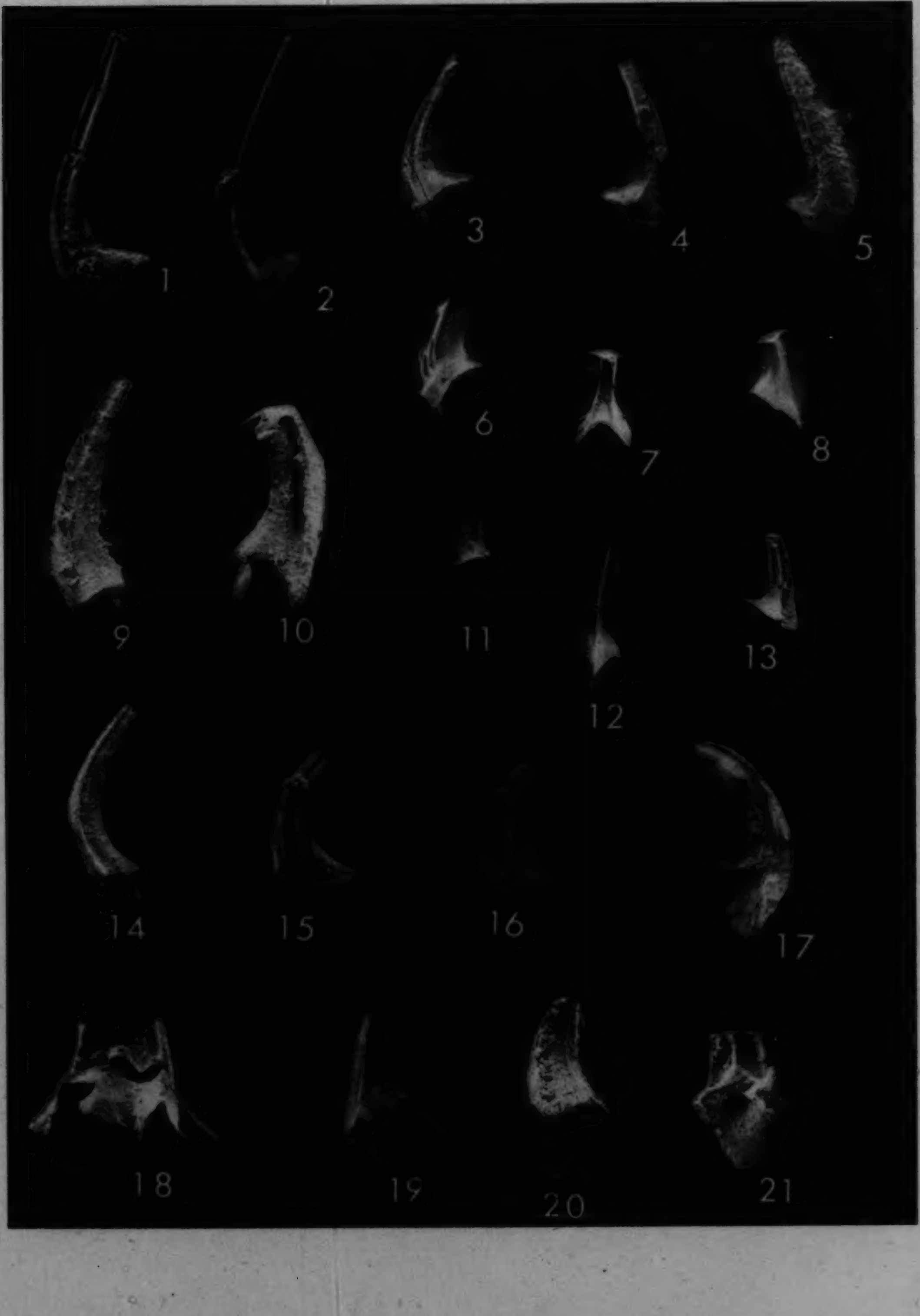
Figs. 6, 7, 8. *Juanognathus jaanussoni* Serpagli. 6,8. Lateral views, GSC50386, GSC50387, X45 (both), D840 (both specimens). 7. Inner view, GSC50388, X45, D840.

Figs. 9-14. *Juanognathus variabilis* Serpagli. 9,10,12,13,14. Inner lateral views, GSC50389, GSC50390, GSC50391, GSC50392, GSC50393, X45 (all), D840 (all specimens). 11. Inner aboral view, GSC50733, X45, D840.

Figs. 15, 16. *Protopanderodus gradatus* Serpagli. Lateral views, GSC50394, GSC50395, X45 (both), D860 (both specimens).

Figs. 17, 20, 21. *Evencodus* sp. aff. *E. sibiricus* Moskalenko. 17. Inner lateral view, GSC50396, X45, S290. 20. Inner lateral view, GSC50397, X45, S290. 21. Inner view, GSC50398, X45, S290.

Figs. 18, 19. *Eoneoprioniodus* ? spp. Lateral views, GSC50399, GSC50400, X45 (both), S290 (both specimens).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## EXPLANATION OF PLATE 18

## WHITEROCKIAN CONODONTS FROM THE SUNBLOOD FORMATION

Figs. 1, 2. Histiodella sinuosa Harris s.f. Lateral views, GSC50410, GSC50411, X60 (both), S290 (both specimens).

Figs. 3, 5. Cordylodus sp. aff. C. horridus Barnes and Poplawski. Lateral views, GSC50412, GSC50413, X60 (both), S290 (both specimens).

Fig. 4. Histiodella sp. A Sweet et al. Lateral view, GSC50414, X45, B310.

Figs. 6, 7, 9. Leptochirognathus n. sp. A. 6. Laterview, trichonodelliform element, GSC50415, X45, E1155. 7. Lateral view, cordylodiform element, GSC50095, X45, E1155. 9. Lateral view, zygognathiform element, GSC50416, X45, E1155.

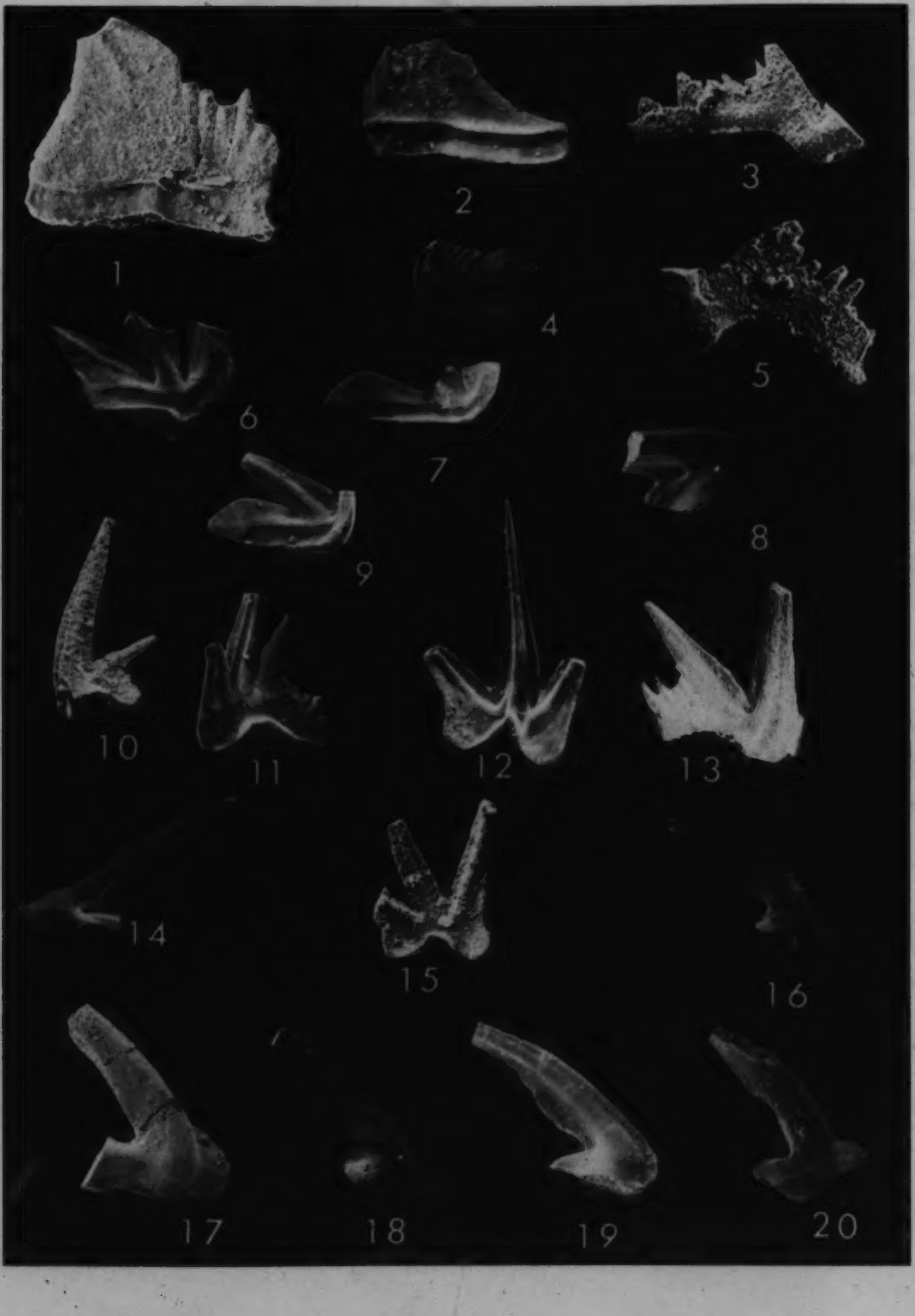
Figs. 8, 14. Oistodus spp. s.f. 8. Lateral view, GSC50097, X45, G1825. 14. Lateral view, GSC50417, X45, S290.

Figs. 10-13, 15. New Genus New Species D. 10. Inner lateral view, dichognathiform element, GSC50419, X45, S290. 11, 15. Inner lateral views, zygognathiform elements, GSC 50420, GSC50742, X45 (both), S290 (both specimens). 12. Inner view, trichonodelliform element, GSC50421, X45, S290. 13. Lateral view, cordylodiform element, GSC50422, S290.

Figs. 16, 18, 20. *Drepanoistodus* ? spp. 16. Lateral view, eoligonodiniform (?) element, GSC50423, X45, G1850. 18,20. Lateral views, oistodiform elements, GSC50424, GSC50740, X45 (both), G1850 (both specimens).

Fig. 17. *Multioistodus subdentatus* ? Cullison. Lateral view, cordylodiform? element, GSC50100, X45, E1155.

Fig. 19. *Distacodus* n. sp. A. Lateral view, drepanodiform element GSC50418, X45, B310.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# EXPLANATION OF PLATE 19

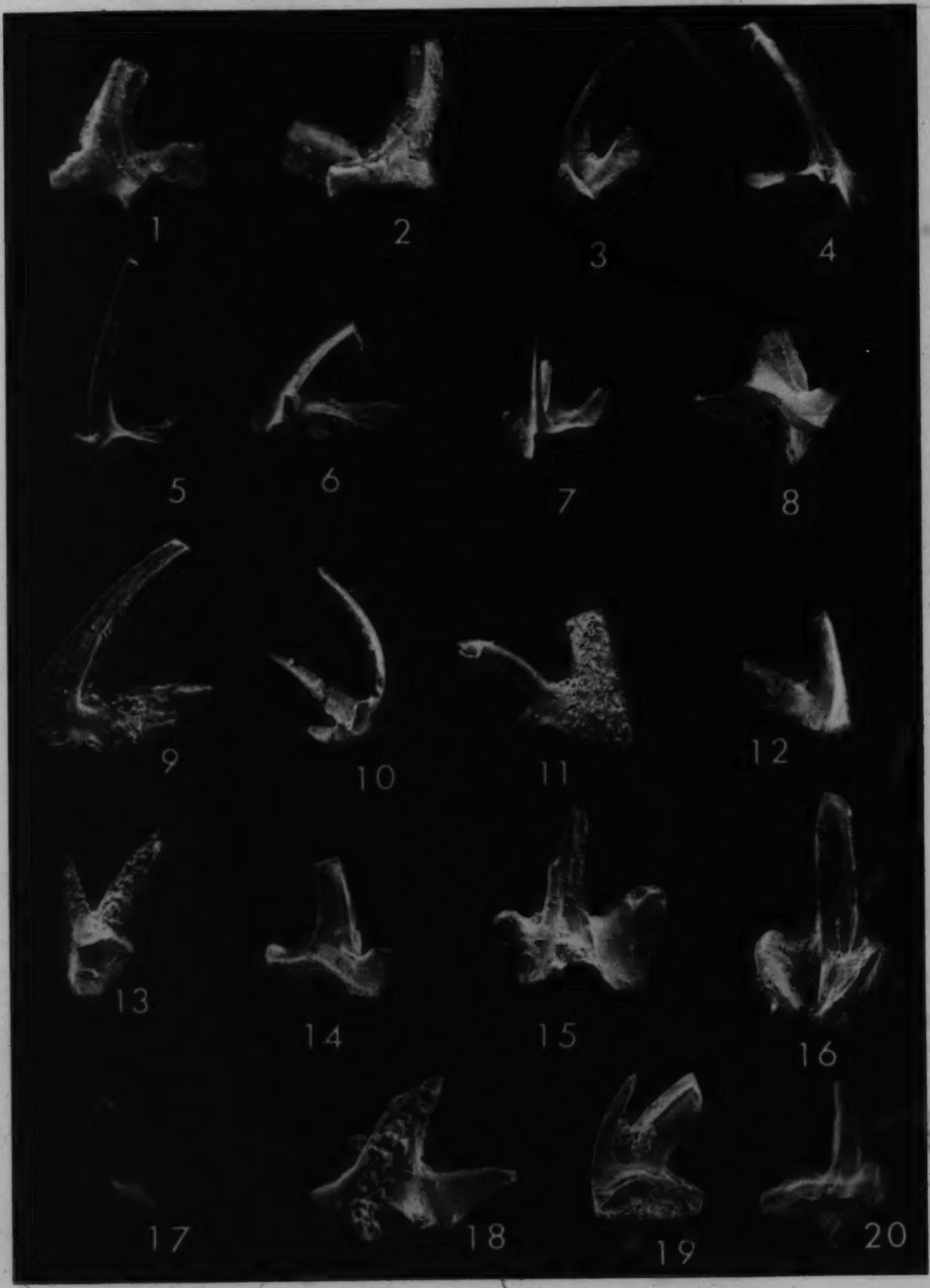
## WHITEROCKIAN CONODONTS FROM THE SUNBLOOD FORMATION

Figs. 1-12. Multioistodus subdentatus Cullison s.l. 1-3. Lateral view, trichonodelliform elements, GSC50424, GSC50425, GSC50092, X45 (all), G1850 (all specimens). 4-8. Lateral view, zygognathiform elements, GSC50426, GSC50427, GSC50428, GSC50429, X45 (all), E1445 (all specimens). 9-12. Lateral view, cordylodiform elements, GSC50432, GSC50433, GSC50434, GSC50435, X45 (all), S290 (all specimens).

Figs. 13-15, 17-19. Multioistodus spp. 13,19. Lateral view, cladognathiform elements, GSC50096, GSC50436, X45 (both), E1445 (both specimens). 14,15. Inner views, roundyaform elements, GSC50430, GSC50431, X45 (both), E1445 (both specimens). 17,18. Lateral views, cordylodiform elements, GSC50437, GSC50107, X45 (both), E1445 (both specimens).

Fig. 16. New Genus New Species C Sweet et al., 1971 s.f. Inner view, GSC50109, X45, B400.

Fig. 20. Pteracontiodus exilis Harris and Harris s.f. Inner view, GSC50438, X45, E1445.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## EXPLANATION OF PLATE 20

## WHITEROCKIAN CONODONTS FROM THE SUNBLOOD FORMATION

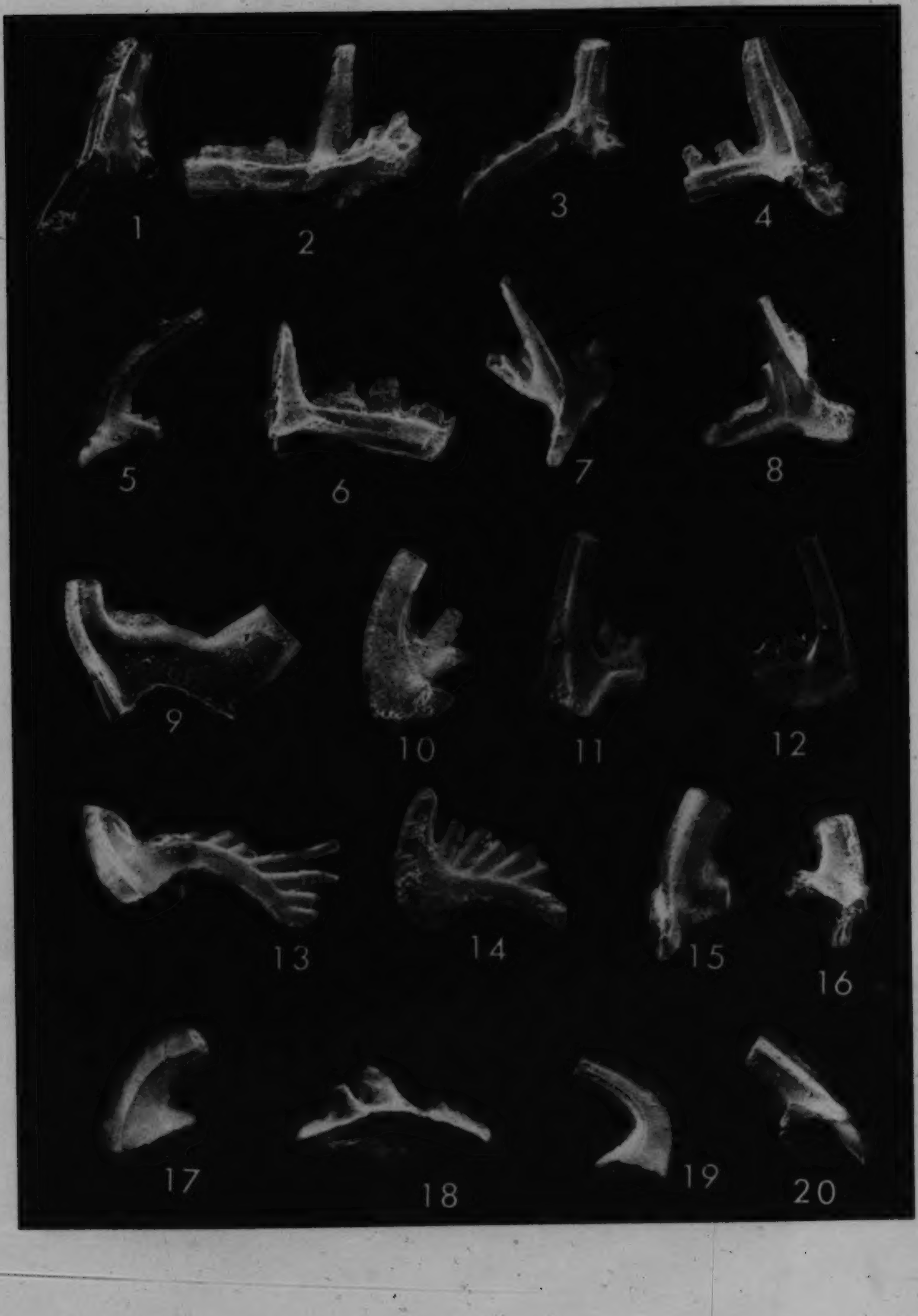
Figs. 1-6. "*Eoneoprioniodus*" n. sp. A. 1. Lateral view, prioniodiform (?) element, GSC50439, X45, P300. 2,6. Lateral view, roundyaform elements, GSC50440, GSC50441, X45 (both), P300 (both specimens). 3. Inner lateral view, cladognathiform element, GSC50442, X45, P300. 4. Lateral view, cordylodiform element, GSC50443, X45, P300. 5. Lateral view, prioniodiform element, GSC50444, X45, P300.

Figs. 7, 8. '*Erismodus*' n. sp. 1 s.f. Outer and outer lateral views, GSC50114, GSC50113, X45 (both), B400 (both specimens).

Figs. 9-16. "*Phragmodus*" n. sp. A. 9. Lateral view, phragmodiform element, GSC50445, X45, P300. 10,13,14. Lateral view, cordylodiform elements, GSC50106, GSC50112, GSC50446, X45 (all), P300 (all specimens). 11,12. Lateral view, cyrtoniodiform elements, GSC50741, GSC50447, X45 (both), P300 (both specimens). 15,16. Outer and inner lateral views, dichognathiform elements, GSC50448, GSC50449, X45 (both), P300 (both specimens).

Figs. 17, 19, 20. *Distacodus* n. sp. A. Inner lateral views, GSC50450, GSC50104, GSC50451, X45 (all), B310 (all specimens).

Fig. 18. *Polycaulodus* ? spp. s.f. Inner view, GSC50452, X45, S290.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## EXPLANATION OF PLATE 21

## MIDDLE ORDOVICIAN CONODONTS FROM THE SUNBLOOD FORMATION

Figs. 1-12. *Oulodus* n. sp. A. 1. Inner lateral view, oulodiform element, GSC50453, X45, B795. ?2. Inner lateral view, ?prioniodiniform element, GSC50454, X45, B795. 4,8. Inner lateral view, ? neoprioniodiform elements, GSC50455, GSC50456, X45 (both), B795 (both specimens). 5. Inner lateral view, zygognathiform(?) element, GSC50457, X45, B795. 7,?3,?6. Inner lateral views, oulodontiform elements, GSC50458, GSC50459, GSC50460, X45 (all), B795 (all specimens). 9,12. Inner lateral views, cyrtoniodiform elements, GSC50738, GSC50461, X45 (both), B795 (both specimens). 10,11. Inner views, trichonodelliform elements, GSC50462, GSC50463, X45 (both), B795 (both specimens).

Figs. 13-20. *Plectodina aculeata* (Stauffer) s.l. 13,15. Inner lateral views, zygognathiform elements, GSC50464, GSC50465, X45 (both), A220, B795 respecitvely. 14. Inner view, trichonodelliform element, GSC50466, X45, A220, B795. 16,17,20. Inner lateral views, cordylodiform elements, GSC50467, GSC50468, GSC50469, X45 (all), B860, P1665, A220 A220 respectively. 18. Inner view, ozarkodiniform element, GSC50470, X45, A220. 19. Inner lateral view, ?dichognathiform element, GSC50471, X45, A220.

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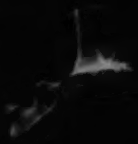
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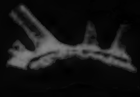
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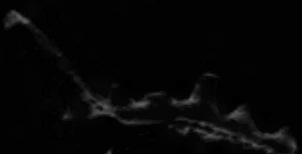
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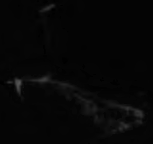
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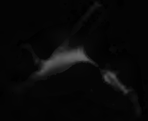
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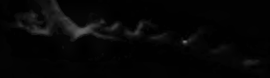
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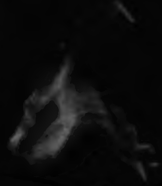
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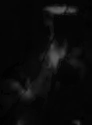
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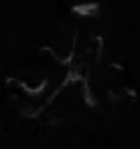
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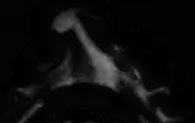
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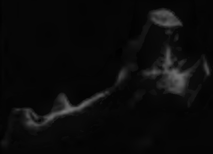
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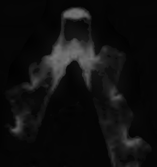
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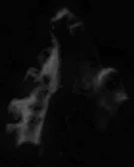
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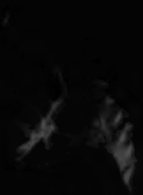
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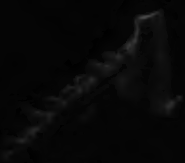
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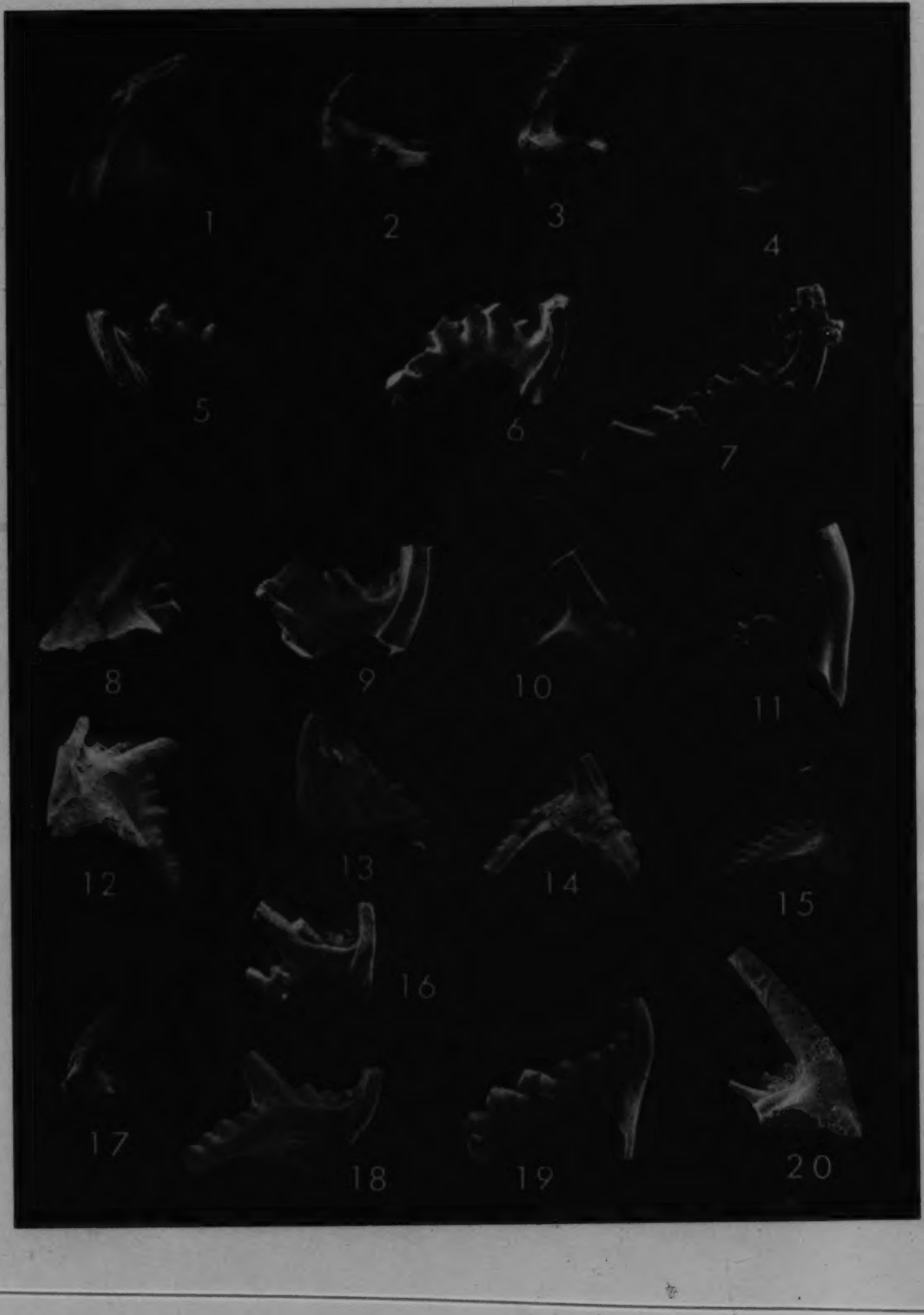
## EXPLANATION OF PLATE 22

## MIDDLE ORDOVICIAN CONODONTS FROM THE SUNBLOOD FORMATION

Figs. 1-11. *Phragmodus flexuosus flexuosus* Moskalenko. 1-4 (early form). 1. Gothodiform element, GSC50472, X30, B795. 2. Phragmodiform element, GSC50473, X30, B795. 3,4. Dichognathiform elements, GSC50739, GSC50474, X30 (both), B795 (both specimens). 5,6. Phragmodiform element, GSC50475, GSC50476, X45 (both), B1100 (both specimens). 7. Cordylodiform element, GSC50117, X45, B1100. 8-11 (late form). 8. Cyrtoniodiform element, GSC50477, X45, P1205. 9. Phragmodiform element, GSC50125, X45, P1205. 10. Dichognathiform element, GSC50478, X45, P1205. 11. Cordylodiform element, GSC50479, X45, P1205.

Figs. 12-15, 18-20. *Phragmodus flexuosus symmetricus* Tipnis, Chatterton and Ludvigsen. 12,13. Phragmodiform elements, GSC50480, GSC50120, X45 (both), A125 (both specimens). 14. Dichognathiform element, GSC50481, X45, A125. 15. Cyrtoniodiform element, GSC50122, X45, A125. 18-20 (late form). 18. Phragmodiform element, GSC50482, X45, A190. 19. Cordylodiform element, GSC50126, X45, A190. 20. Cyrtoniodiform element, GSC50127, X45, A190.

Figs. 16, 17. *Phragmodus inflexus* Stauffer. 16. Phragmodiform element, GSC50154, X45, P1665. 17. Dichognathiform element, GSC50155, X45, P1665.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## EXPLANATION OF PLATE 23

## MIDDLE ORDOVICIAN CONODONTS FROM THE SOUTHERN MACKENZIE MOUNTAINS

Figs. 1-4, 7. Appalachignathus delicatulus Bergström et al. 1. Lateral view, eoligonodiniform element, GSC50143, X60, P1730. 2. Inner view, trichonodelliform element, GSC50148, X60, P1730. 3,7. Lateral views, spathognathodiform elements, GSC50484, GSC50152, X60 (both), P1730 (both specimens). 4. Lateral view, zygognathiform element, GSC50149, X60, P1730.

Fig. 5. Acodus mutatus (Branson and Mehl). Lateral view, distacodiform element, GSC50485, X60, H1020.

Fig. 6. Oistodus nevadensis Ethington and Schumacher s.f. Lateral view, GSC50160, X60, H1020.

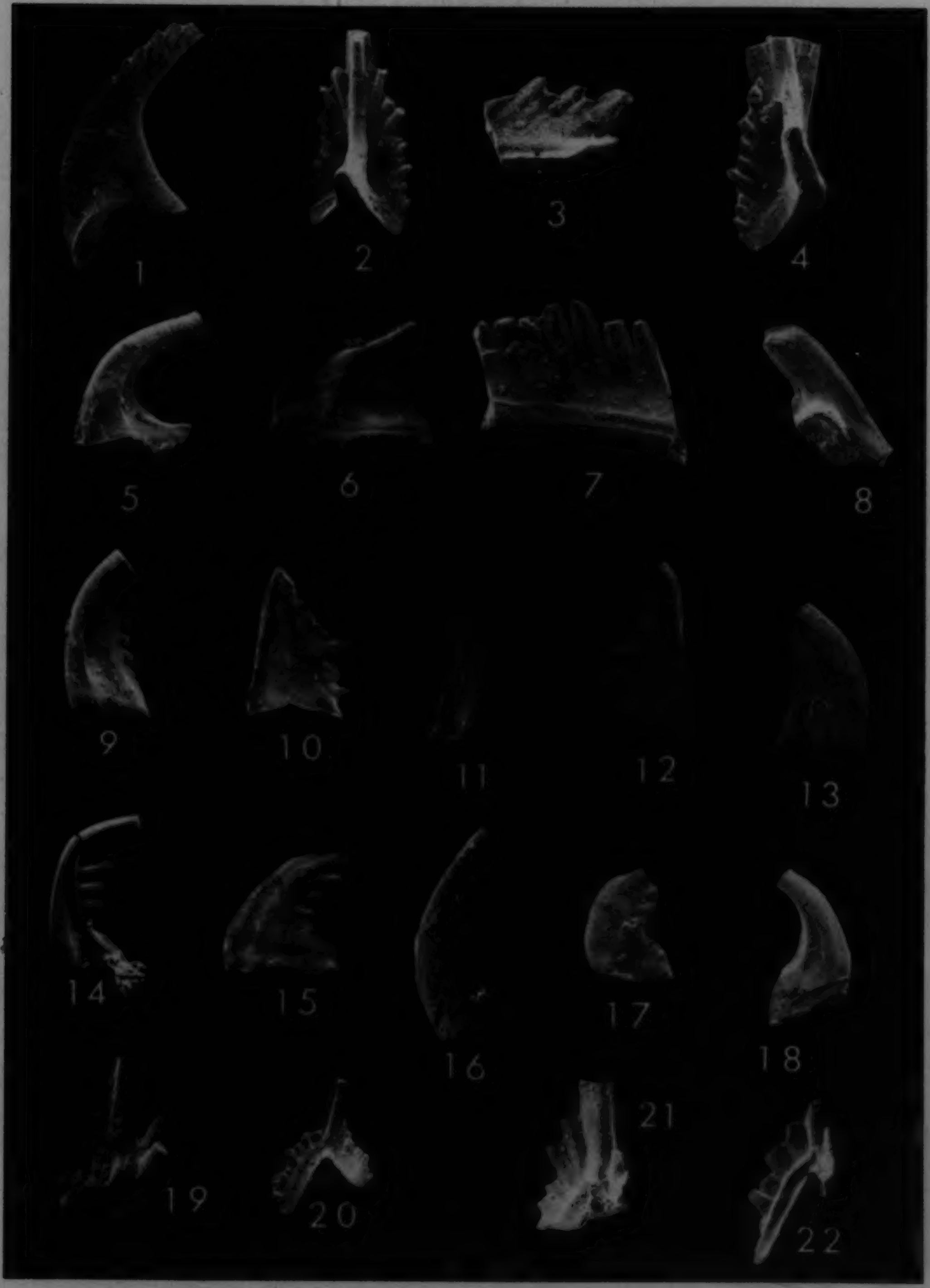
Figs. 8, 19. Plectodina aculeata (Stauffer). 8. Inner lateral view, oistodiform element, GSC50486, X60, P1665. 19. Inner lateral view, zygognathiform element, GSC50487, X60, B1100.

Figs. 9, 14, 15, 17. Belodina compressa (Branson and Mehl). Lateral views, belodiniform elements, GSC50715, GSC50488, GSC50489, GSC50128, X60 (all), E2440, E2540, E2700, P525 respectively.

Figs. 10-12. Belodella erecta (Rhodes and Dineley). Lateral views, GSC50490, GSC50491, GSC50153, X60 (all), P1625, P1625, P1730 respectively.

Figs. 13, 16, 18. Panderodus gracilis (Branson and Mehl). Lateral views, GSC50165, GSC50492, GSC50493, X60 (all), H1020, P1730, M1720, respectively.

Figs. 20-22. Rhipidognathus ? n. sp. A. 20. Inner view, zygognathiform element, GSC50494, X45, B1005. 21. Inner view, trichonodelliform element, GSC50495, X45, B1005. 22. Inner lateral view, cordylodiform element, GSC50496, X45, B1005.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## EXPLANATION OF PLATE 24

## MIDDLE ORDOVICIAN CONODONTS FROM THE SOUTHERN MACKENZIE MOUNTAINS

Figs. 1, 5-8. *Triangulodus* n. sp. B. 1. Lateral view, drepanodiform element, GSC50164, X60, P1730. 5. Lateral view, scandodiform element, GSC50497, X60, P1730. 6. Lateral view, acodiform element, GSC50498, X60, P1730. 7. Posterior view, trichonodelliform element, GSC50499, X60, P1730. 8. Lateral view, zygognathiform element, GSC50560, X60, P1730.

Fig. 2. *Staufferella lindstroemi* (Ethington and Schumacher). Inner lateral view, GSC50503, X60, P1625.

Figs. 3, 4. *Staufferella falcata* (Stauffer). 3. Inner lareral view, acontiodiform element, GSC50501, X45, P1585. 4. Inner lateral view, acontiodiform element, GSC50502, X45, E2540.

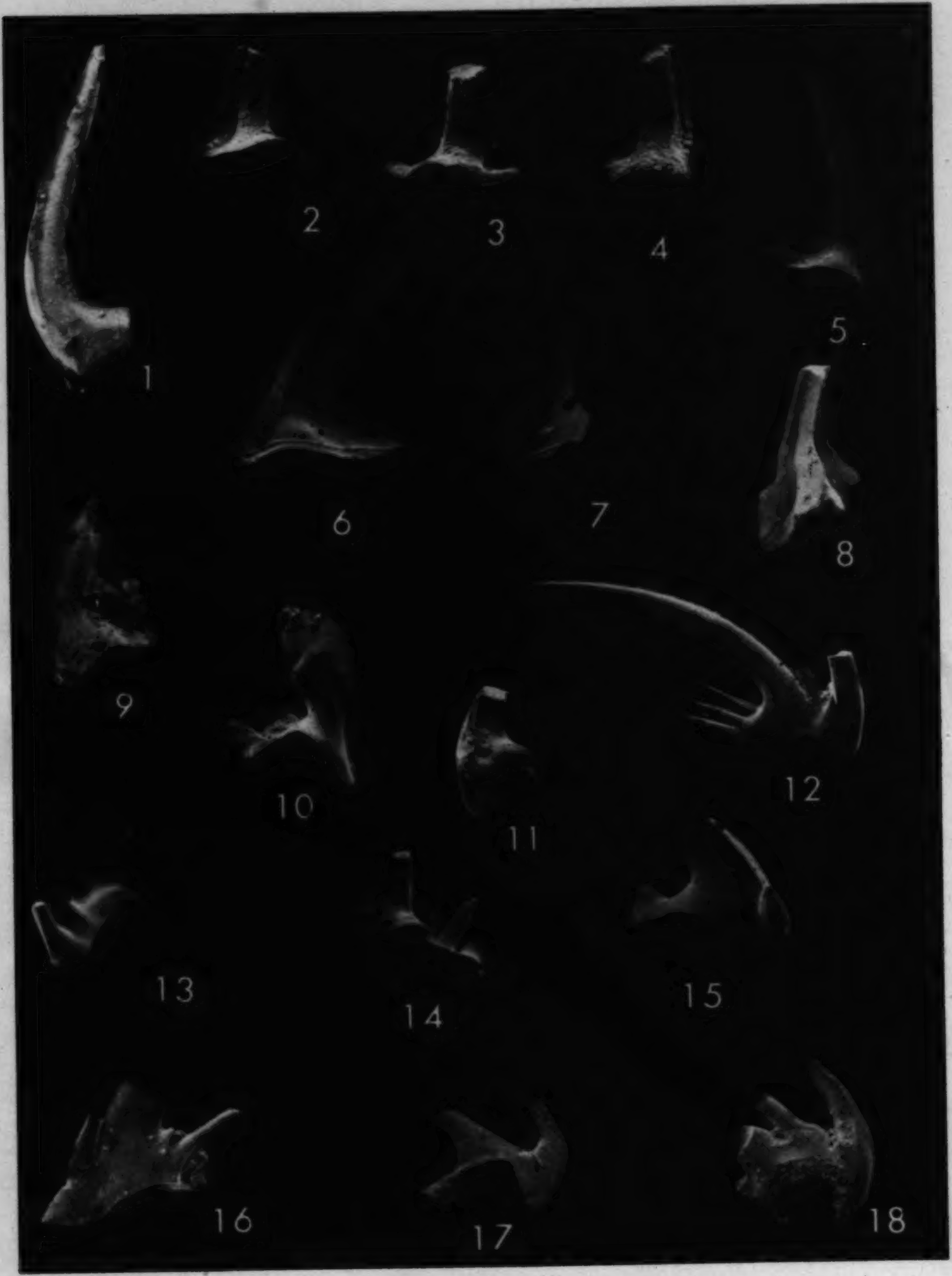
Fig. 9. *Cyrtoniodus* sp. 1 s.f. Inner lateral view, GSC50504, X60, A190.

Fig. 10. *Cyrtoniodus* sp. 2 s.f. Inner lateral view, GSC50505, X60, A190.

Figs. 11, 13-15. "*Erismodus*" sp. A. 11. Inner lateral view, trichonodelliform element, GSC50506, X60, A190. 13. Lateral view, zygognathiform element, GSC50507, X60, A190. 14. Inner lateral view, trichonodelliform element, GSC50508, X60, A190. 15. Lateral view, cordylodiform element, GSC50509, X60, A190.

Figs. 12, 16. "*Ptiloconus?*" *strachagnathoides* Moskalenko. 12. Lateral view, GSC50510, X60, P725. 16. Lateral view, GSC50511, X60, P725.

Figs. 17, 18. Phragmodus n. sp. 1 s.f. 17. Lateral view, GSC50512, X60, H1020. 18. Lateral view, GSC50513, X60, H1020.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# EXPLANATION OF PLATE 25

## MIDDLE ORDOVICIAN CONODONTS FROM THE SOUTHERN MACKENZIE MOUNTAINS

Fig. 1. Scyphiodus sp. s.f. Oral view, GSC50156, X60, P1730.

Figs. 2-4, 12, 13. Erismodus spp. 2-4,12. All inner lateral views, GSC50514, GSC50133, GSC50515, GSC50132, X60 (all), P1730, P1730, P1730, P1127 respectively. 13. Inner lateral view, GSC50522, X45, P1127.

Figs. 5, 6. Leptochirognathus quadratus Branson and Mehl. 5. Inner lateral view, GSC50516, X60, A100. 6. Inner lateral view, GSC50517, X60, A100.

Figs. 7, 11. Chirognathus monodactylus Branson and Mehl. Inner lateral views, GSC50518, GSC50519, X60 (both), P1405 (both specimens).

Fig. 8. Chirognathus n. sp. 1 s.f. Inner lateral view, GSC50139, X60, P1405.

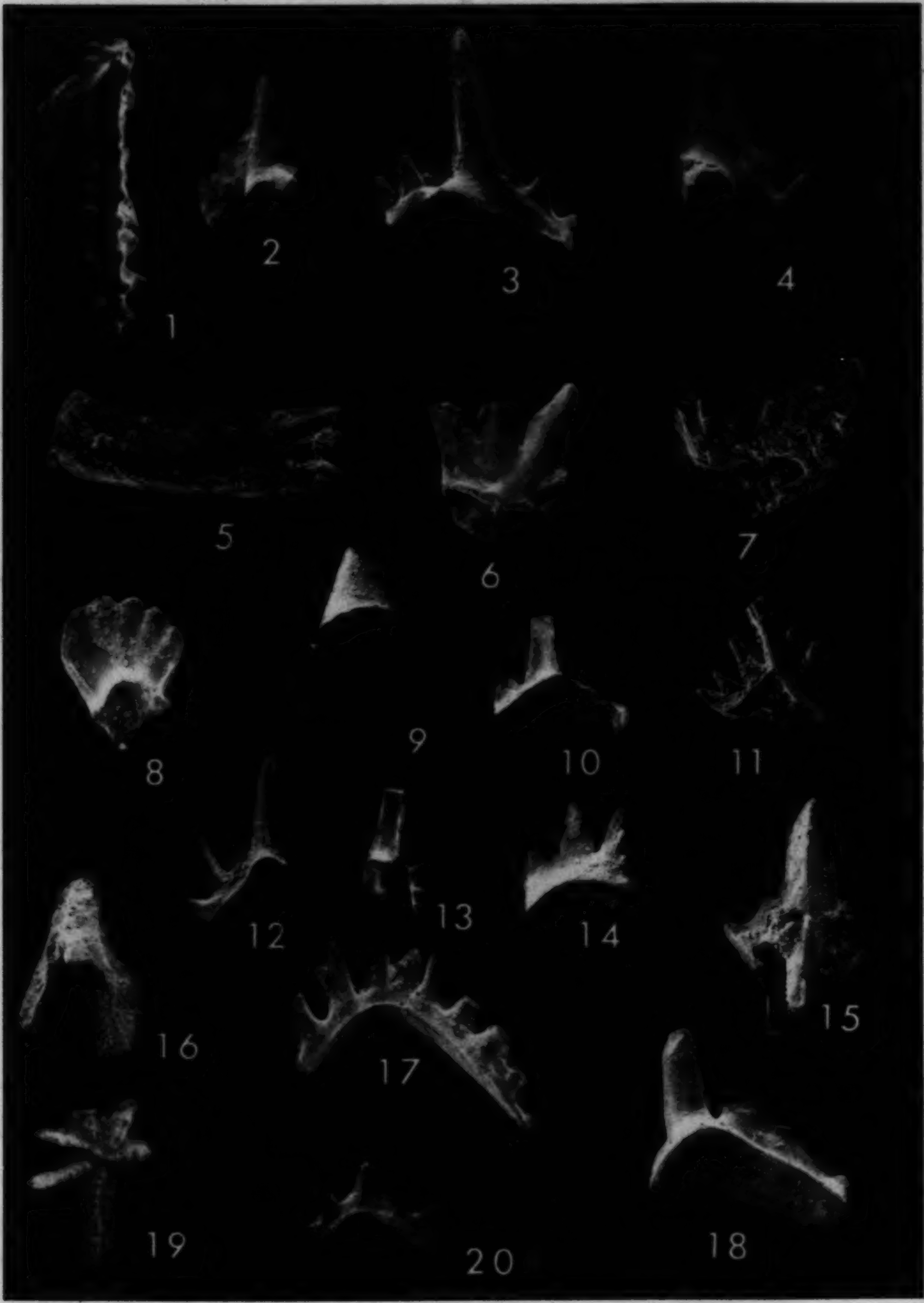
Fig. 9. Stereoconus sp. s.f. Aborolateral view, GSC50520, X60, P1405.

Figs. 10, 18. Polycaulodus bidentatus Branson and Mehl. Inner lateral views, GSC50130, GSC50525, X60 (both), P525 (both specimens).

Figs. 14, 17, 20. Curtognathus typus Branson and Mehl. Inner lateral views, GSC50521, GSC50524, GSC50131, X60 (all), P525 (all specimens).

Figs. 15, 16. Erismodus ? spp. 15. Aborolateral view, GSC50523, X60, P525. 16. Lateral view, GSC50134, X60, P525.

Fig. 19. Polyplacognathus ramosus Stauffer. Oral view, GSC50157, X45, P1665.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## EXPLANATION OF PLATE 26

## CONODONTS FROM THE WHITTAKER FORMATION

Figs. 1, 4, 9. *Aphelognathus kimmswickensis* Sweet *et al*. 1. Lateral view, P element, GSC50166, X60, E2740. 4. Posterior view, $A_2$ element, GSC50167, X60, E2740. 9. Posterior view, $A_3$ element, GSC50168, X60, E2740.

Figs. 2, 3, 5-8, 10, 12 -14. *Plectodina furcata* (Hinde) s.l. 2. Lateral view, $A_1$ element, GSC50169, X60, E2700. 3,5. Lateral views, P elements, GSC50170, GSC50171, X60 (both), E2740 (both specimens). 6. Posterior view, $A_2$ element, GSC50172, X60, E2740. 7. Lateral view, $O_1$ element, GSC50173, X60, E2700. 8. Inner lateral view, $O_1$ element, GSC50174, X60, E2700. 10. Posterior view, $A_3$ element, GSC50175, X60, E2700. 12,14. Lateral views, N elements, GSC50176, GSC50177, X60 (both), $\overset{P}{R}$2740 (both specimens). 13. Lateral view, $A_1$ element, GSC50179, X60, E2700.

Fig. 11. *Staufferella falcata* (Stauffer). Illustrated on Plate 24, mag. X60.

Fig. 15. *Belodina* aff. *B*. *inclinata* (Branson and Mehl) s.f. Lateral view, GSC50180, X60, E2740.

Fig. 17. *Bryantodina* ? *abrupta* (Branson and Mehl). Lateral view, GSC50181, X30, E2740.

Fig. 18. Form P. Oral view, GSC50182, X60, E2625.

Fig. 19. *Amorphognathus* sp. A ? Oral view, GSC50183, X60, E2445.

Fig. 20. *Acodus* cf. *A*. *numaltipes* Schopf s.f. Lateral view, GSC50184, X60, M1820.

Fig. 21. New Genus New Species 3. Lateral view, GSC50185, X90, E2740.

Figs. 16, 22-24. Panderodus gracilis (Branson and Mehl). 16. Lateral view, GSC50186, X60, I1410. 22. Lateral view, GSC50187, X60, J220. 23. Lateral view, GSC50188, X60, M1720. 24. Lateral view, GSC50189, X60, D1665.

Figs. 25-27. Drepanoistodus suberectus (Branson and Mehl).

25. Lateral view, oistodiform element, GSC50190, X60, E2740.

26. Lateral view, drepanoistodiform element, GSC50191, X60, E2740.

27. Lateral view, drepanodiform element, GSC50192, X60, E2740.

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## EXPLANATION OF PLATE 27

## PROBLEMATIC MICROFOSSILS AND 'CONODONTS' (?) FROM THE SOURTHERN MACKENZIE AREA

Fig. 1. Form A. Inner lateral view, GSC50001, X60, K390.

Fig. 2. Form B. Inner view, GSC50000, X60, K270.

Fig. 3. Form C. Lateral view, GSC50700, X60, K390.

Fig. 4. Form D. Lateral view, GSC50701, X60, K390.

Fig. 5. "Drepanodus" spp. s.f. Lateral view, GSC50702, X60, K715.

Fig. 6. Form E. Lateral view, GSC50003, X45, K390.

Fig. 7. Form F. Lateral view, GSC50703, X45, K1150.

Fig. 8. Form G. Lateral view, GSC50704, X45, K715.

Fig. 9. Form H. Oral view, GSC50705, X45, K1150.

Fig. 10. Form I. Oral view, GSC50706, X30, K2375.

Fig. 11. Form J. Front view?, GSC50707, X45, A220.

Fig. 12. Form K. Oral view, GSC50708, X45, D1680.

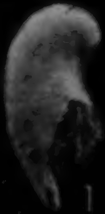
Fig. 13. Form L. Inner lateral view, GSC50709, X45, Loc. 5.

Fig. 14. Form M. Inner view, GSC50710, X45, D450.

Fig. 15. Form N. Oral view, GSC50711, X45, Loc. 5.

Fig. 16. Form O. Oral view, GSC50712, X45, K860.

Fig. 17. Aconthodus ? sp. s.f. Lateral view, GSC50713, X60, P1720.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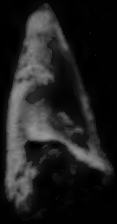
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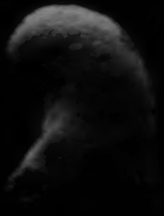
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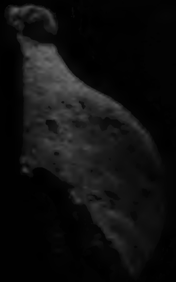
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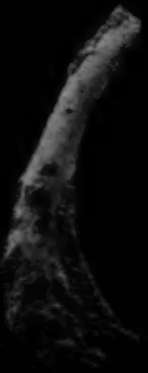
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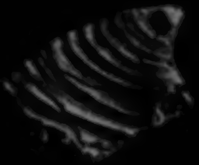
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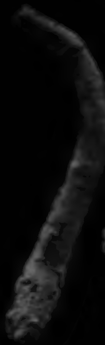
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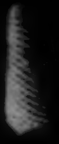
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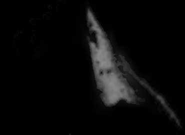
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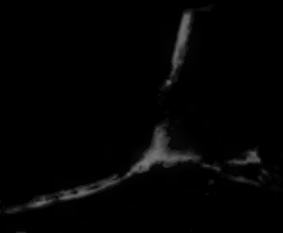
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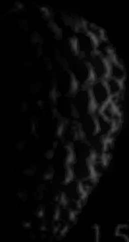
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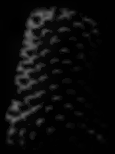
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